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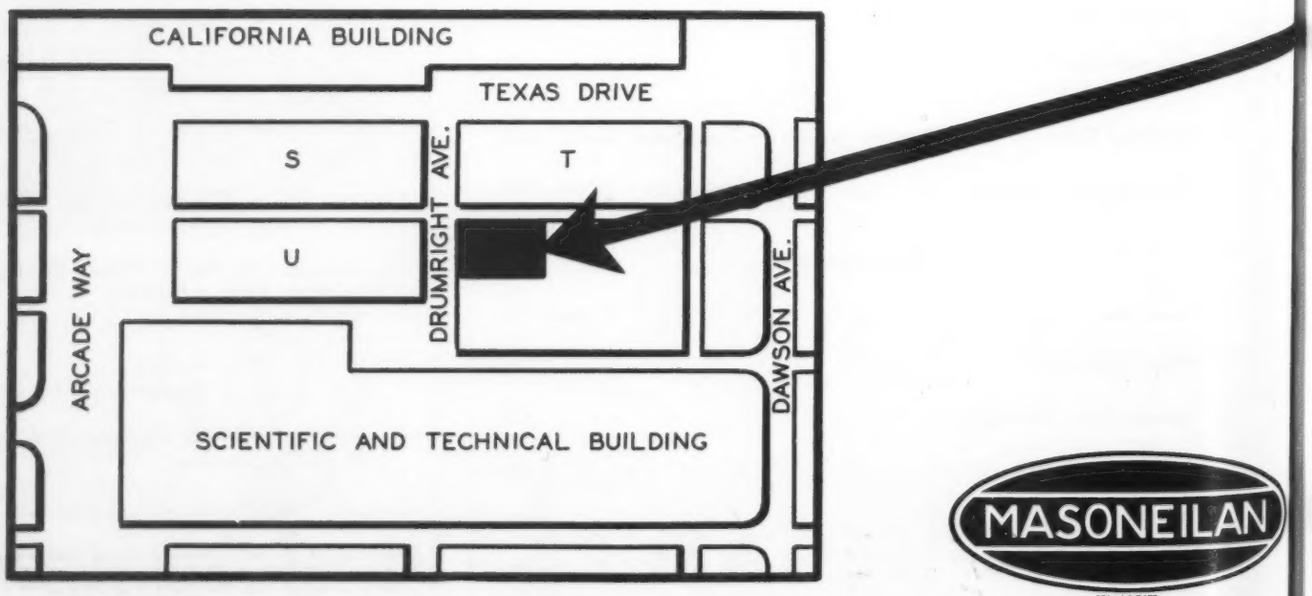

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VOLUME 19, No. 5 MAY, 1940

REFINER
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The Look Box

FREQUENTLY statements are made that the manufacture of gasoline from natural or casinghead gas is a part of the producing division of the petroleum industry. No more convincing argument to the contrary can be found than the annual convention of the Natural Gasoline Association of America. For three days each year a few hundred men meet to study technical progress of an industry that exists within the pertroleum industry.

Industry Within An Industry

Nineteen years ago when the association was formed natural gasoline (then casinghead gasoline) held a different position. The product was without specifications and without individual standing. Plants simply extracted whatever they could get and sold whatever weather and other handicaps would permit to reach the market. The working out of rigid specifications and the technical accomplishments essential to reaching them were in large measure the result of cooperative work within the association.

Natural gasoline now goes to several markets as a tailor-made product. It may be natural gasoline for refinery blending, butane for motor fuel or bottled gas for domestic use. Recently the refining industry has learned how to make use of phases of natural gasoline manufacture in its catalytic processes, whereby recovery is increased and quality of motor fuel improved.

Perhaps the outstanding contribution of the Natural Gasoline Association of America was its successful campaign to bring the product into favor as a part of motor fuel for improvement in both volatility and anti-knock performance. Technical advances under association sponsorship have touched so many phases that a list would be imposing but add little proof to the claim that natural gasoline is an entity in itself.

Recently the distillate recovery threw a problem into the hands of the producing division of the petroleum industry. By coming into this field the technique of natural gasoline manufacture took over and promptly converted these fields into sources of profit. Had there been no natural gasoline industry, there would today be little production of distillate, except by simple stage separation, which would give its owner a product without specifications and with no more standing than natural gasoline had 20 years ago. The modern distillate or recycling plant, however, may provide both motor fuel and kerosene, each made to exact specifications.

Compared with refining or with production, natural gasoline is not imposing. What is signifi-

cant is that this industry within an industry has it own technology, its own operating personnel, its own specifications and its own research program. It has covered its ground and left evidence of its progress. It is headed in a known direction and has definite problems to solve.

Only an essential industry could support an organization such as the Natural Gasoline Association of America. Its existence, its growth and its program are evidence that it is an industry within an industry.

THE following analysis of the alkylation process and what it means to the manufacture of natural gasoline is from the April, 1940 "Industrial Bulletin" of Arthur D. Little, Inc.

Alkylation and Natural Gasoline

"Starting some years ago and becoming intensified recently, there has been a movement on the part of petroleum refiners to boost anti-knock quality of gasoline. Such a boost in anti-knock quality or 'octane number,' while quite welcome to the consumer and meeting the progressively increasing average compression ratio or knock-tendency of automobiles, tends to become a competitive race and an extra burden for the producer of petroleum products.

"In much of the gasoline now sold such a boost in performance quality is readily attainable by a simple increase in the proportion of tetraethyl lead used; but some refiners have never subscribed to the use of 'lead' and for all refiners an increase in the amount of 'lead' means added cost. Furthermore, the improvement in anti-knock quality decreases as more 'lead' is used, and there are technical limits to the amount that may be added. Other octane-raising factors include the new catalytic processes for breaking down heavy petroleum fractions and building up light ones, and the thermal 'reforming' of low anti-knock gasoline. Quite recently a new tool, alkylation, has been proclaimed and promises to be of particular value in meeting the growing demand for high-octane aviation gasoline, although it is as yet too expensive for extensive use in automobile fuel blends.

"The alkylation process causes the traditionally inert paraffin, or hydrogen-saturated, hydrocarbons to combine with the highly reactive olefin, or hydrogen-deficient, hydrocarbons to form new and useful compounds. At present the only suitable saturated reactant is isobutane, a four-carbon-atom refinery gas component in which the carbon atoms are arranged to form a branched chain. In one alkylation process, isobutane is heated with light olefins to form the superfuel, neohexane; in another process a somewhat heavier olefin, butylene, is catalytically reacted with isobutane to form octane mixtures high in anti-knock properties. The process permits enhanced yields of superlative non-knocking motor fuels from refinery waste gases and from mixtures with rich natural gas without the necessity for a preliminary cracking of the natural gas to render it reactive. Furthermore, in the alkylation process it is no longer necessary to add hydrogen to the product, as was required to complete saturation of the gasoline obtained by combining two unsaturated hydrocarbons. Besides having a high anti-knock value, the products of alkylation are said to be stable toward light and air, have a pleasant odor, respond readily to increase in anti-knock quality by tetraethyl lead addition, burn cleanly in engines, and to release a large amount of heat on combustion.

"Heretofore, utilization of the gaseous hydrocarbons for gasoline manufacture has depended upon having them in a reactive, hydrogen-deficient condition. Since such hydrogen deficiency does not occur in natural gas without a cracking operation and is present in only some of the components of refinery cracked gases, gasoline synthesis has been largely limited to these components and to use of natural gas in a process causing both cracking and combining to take place.

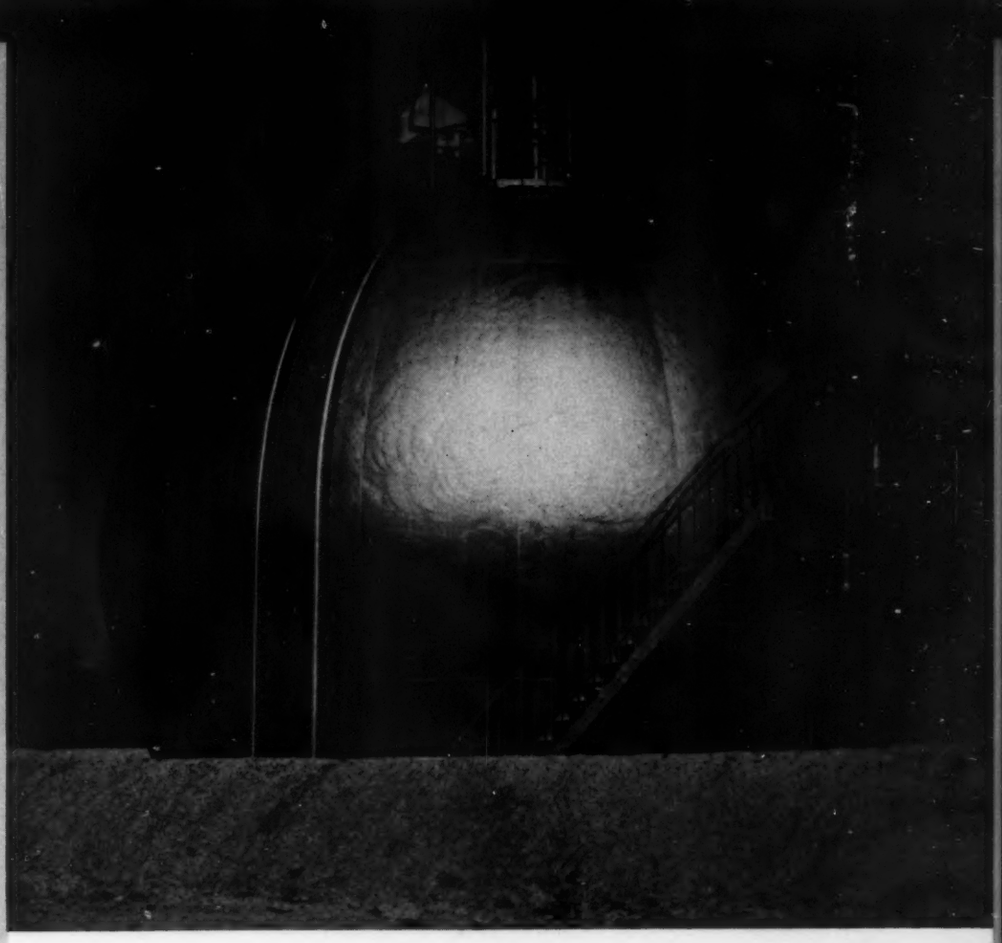
"In general the lighter hydrocarbon compounds do not knock so much as the heavier ones of the same type. In view of this, and to improve motor fuel volatility as well as to obtain as large a volume of liquid fuel as possible, refiners have made a practice of including as much of the light butane, or four-carbon-atom, hydrocarbons as possible in gasoline. The use of butane is limited, however, by vapor lock in hot weather and excessive losses by evaporation. The surplus butane, now used extensively as a domestic and industrial fuel, is an attractive starting point for gasoline synthesis and a portion of the butane cut finds ready application in the alkylation process.

"At present, however, only the branched-chain, or isobutane, portion of the butane hydrocarbons is suitable for alkylation. The supply of isobutane is limited and natural gasoline plants are now being called upon to augment that available from refinery gases. If normal butane were usable for alkylation, a higher-grade market would be created for the butane gases and, because of increased use of the alkylation process, a larger market for the readily available hydrogen-deficient reactants would thereby become possible. There are indications that this may become possible through a new process, referred to as isomerization, which changes normal butane to isobutane."

IN this paper the authors have discussed development and recovery methods in the distillate pools in the Gulf Coast.

Reservoir conditions in these deep fields have brought many new engineering problems, well spacing, pressure maintenance, and recycling, as well as problems for distillate recovery.

The several conventional distillate-extraction processes are described and the importance of gas conservation has been brought out.



L. S. REID
Black, Sivalls & Bryson

R. L. HUNTINGTON
University of Oklahoma

Recent Developments in Distillate Recovery

CONTINUED discovery of deep-seated distillate reservoirs in the Gulf Coast areas has caused the petroleum industry to focus much of its attention upon this region. As late as 10 years ago, petroleum engineers had no idea that deeper pools would contain fluids exhibiting different physical properties than those found at depths of 6500 feet and less. Although major fields such as Kettleman Hills, which might be put in the distillate class, had already been discovered, engineers did not realize a single-phase fluid existing in a reservoir under high pressure could partially liquefy when its pressure was reduced through a certain range.

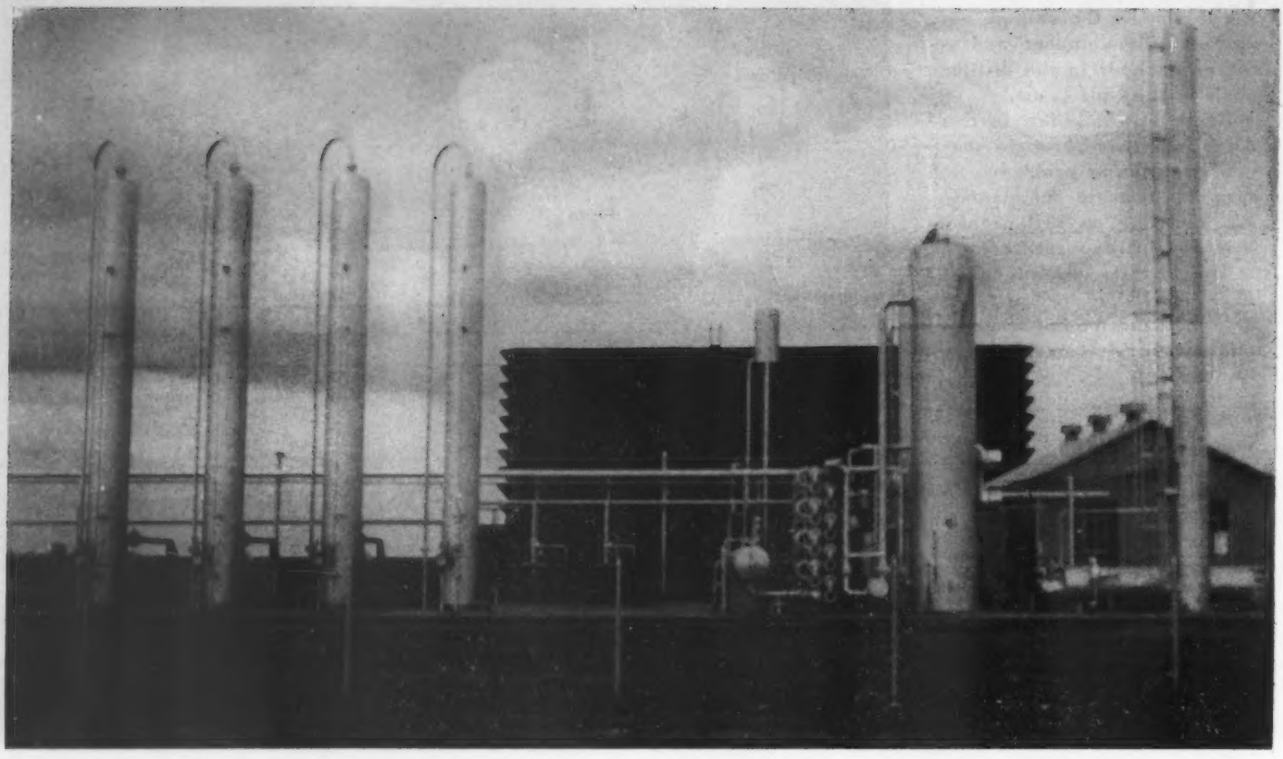
Early Observers of Retrograde Condensation

Weber[15] has brought out the interesting fact that the phenomenon of retrograde condensation, or the tendency for single-phase "vaporous" fluids to partially condense upon pressure reduction, was first observed by Cailletet[1] as early as 60 years ago when he was working with mixtures of air and carbon dioxide under high pressures. In 1892, Kuenen[11] who was also studying this phenomenon, termed this unexpected trend "retrograde condensation." It might just as well have been called "retrograde vaporization," as a means of conveying a word picture of the physical change. Little attention was paid to these early findings because industrial processes have only recently required high pressures such as 1000 to 10,000 pounds per square inch.

During the past decade, industrial and university researchers[2, 9, 13, 4] have contributed much valuable information through investigation of pressure-volume-temperature relationships both of the pure hydrocarbons and of crude oil-gaseous mixtures. Research activity along this line is more pronounced now than it has ever been, since refiners are equally interested in high-pressure operations in the catalytic and thermal processes which are being developed for the manufacture of synthetic motor fuels.

Importance of Pressure Maintenance

The benefits to be gained through maintenance of pressure on fields containing only liquefied fluids as well as those having two phases present (liquid and



High-Pressure Absorption as used extensively in the distillate area of South Texas.

gas) have been well recognized for 15 to 20 years. Air and gas recycling and repressuring operations were carried out in the twenties in the shallow pools of Kansas and Oklahoma as a means of recovering more oil from partially depleted formations. The return of dry residue gas to the deep distillate pools has taken on added points of significance which were not important to the early-day pools.

(1) *Gas Conservation*

Heavy penalties have recently been placed on wells which produce with a high ratio of gas to liquefied hydrocarbons, through a reduction in allowables on a graduated scale, even to the shutting in of those wells which might exceed certain limits, such as 50 to 100 thousand cubic feet per barrel of oil or of distillate. Availability of a fuel market for residue gas, or a storage space for such gas generally precludes such drastic regulations. Since the fuel market is limited in comparison to the volumes of producible gas, the second alternative of returning gas to the formation seems to be the logical means of speeding up the rate of payout through the securing of increased allowables.

(2) *Single Phase Retention Through Pressure Maintenance*

Since distillate recovery must depend upon very wide spacings (of the order of 80 to 320 acres per well) for a reasonably high return on investment, it is essential that no liquid phase be formed in the reservoir through pressure decline. Closer spacings might speed up the rate of production and result in a quicker payout, however, the number of payouts would be reduced through increased investment costs. Through the return of residue gas to the formation by compression, the reservoir is maintained at substantially constant pressure throughout the producing life of the field and the distillate-bearing fluid is kept in a single-phase state. Furthermore, this dry recycle gas acts as a stripping or denuding agent should some liquefaction occur in the lower-pressure regions of the formation, causing vaporization due to the low partial pressure of the distillate constituents of the dry gas. This denuding action, however, would be slow as the linear velocity of the dry gas through the formation would be at greatly retarded rate. In other words, the slow process of diffusion would take place between the relatively stagnant masses of gas and liquid. For this reason, it would be best to prevent condensation from taking place within the formation at all times by keeping the lowest pressure areas around the well bores considerably above the retrograde range. In formations of low permeability, this maintenance of high pressure near the well bores might call for greatly reduced production rates.

(3) *Reduction of Gas Mixing in the Formation*

There are little field data to show how much mixing is occurring between the dry recycle gas and the distillate-bearing fluid. Indications from first results obtained in several repressuring operations in distillate pools point toward an inappreciable amount of intermixing. The only experimental work which has been reported in the literature so far is that which Ducker et al[3] have done on the mixing of air and a natural gas (0.6 sp. gr.) in Wilcox sand at atmospheric pressure. From this laboratory work it has been found that high linear velocities result in less mixing in a 4-inch x 5-foot tube, but with close spacing for three dimensional flow in a sand-packed drum, low velocities are conducive to less mixing.

The American Gas Association and the Natural Gas Supply Men's Association are sponsoring further research on this problem at the University of Oklahoma. This year's initial results, at elevated pressures, indicate that the mixing tendency will be greatly diminished. This news will be encouraging to the distillate producers as it will mean far less recycling of dry gas in order

to effect a quantitative expulsion of the virgin distillate fluid from the reservoir.

(4) *Prevention of Edge Water Encroachment*

Water drive would cause displacement of the distillate phase, if the water table would progress as a straight edge. Lack of homogeneity in the formation would prevent such an ideal process from being accomplished, with the result that some distillate areas would be encircled and trapped off. The maintenance of p.essure through the return of recycle gas should cause a retardation, or stoppage of any water-flood tendency and thereby provide a constant volumetric gas pore space for storage of dry recycle gas to be used at some future date for fuel or for some pyrolytic process by converting these lower hydrocarbons (predominantly methane) into more useful products.

Optimum Recycling Pressures

Determination of an equation expressing the cost of recovering distillate production by condensation in terms of one variable such as the pressure on the first-stage separator is complicated by a number of factors. In the first place, no two distillate reservoirs have the same combination of items such as:

(1) Permeability.
(2) Thickness and extent of formation.
(3) Composition of reservoir fluid.
(4) Reservoir pressure.
(5) Relative value of distillate to that of dry gas.

An attempt at a mathematical solution of the problem might be made, however, as a means of obtaining a clearer insight into a certain puzzling situation. Assuming that the above five mentioned items are fixed, the variables would be those of recompression cost and distillate return both as a function of the pressure on the first-stage separator. The cost of compression will be proportional to the logarithm of the ratio of the discharge pressure to the suction pressure, while stage separation cost will be some function of the first-stage separator pressure. The optimum pressure could be determined, setting the first differential of the total cost to the first-stage pressure equal to zero and then solving for the desired pressure. This pressure would be expected to fall around 100 to 300 pounds above the pressure which would bring the greatest yield of distillate. Each situation would present all of the other variables for consideration, therefore, the graphical method would no doubt have to be depended upon for a final solution.

TABLE 1

COMPOSITION	Case A	Case B
C_1 Methane	93.405	80.851
C_2 Ethane	3.008	7.449
C_3 Propane	1.024	3.454
i C_4 Iso-butane	0.125	1.345
n C_4 Normal butane	0.678	1.270
i C_5 Iso-pentane	0.195	....
n C_5 Normal pentane	0.150	....
Total C_5—Pentanes	....	5.631
Hexanes—C_6	1.415	....
Total percent	100.000	100.000
Total C_4 + Butanes	1.020 gpm	3.355 gpm
	or 24.32 bbl/mm	or 79. 8 bbl/mm
Total C_5 + Pentanes	.765 gpm	2.515 gpm
	or 18.22 bbl/mm	or 59.80 bbl/mm

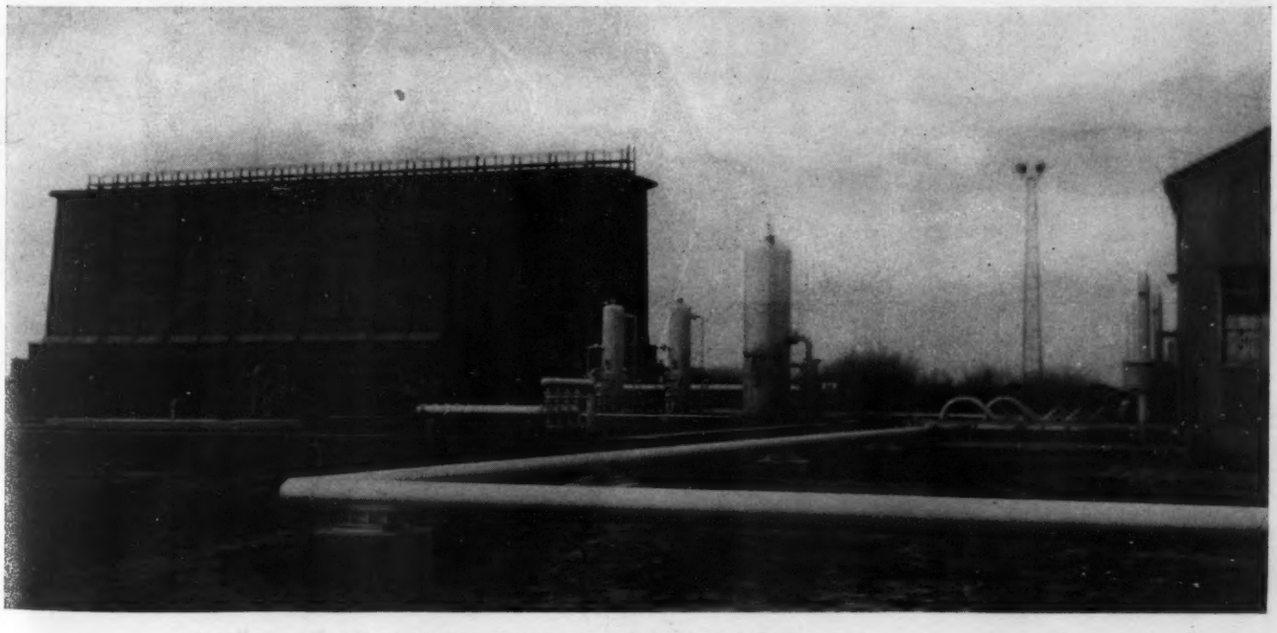
Recovery Processes

The task which confronts an efficient distillate-recovery process becomes apparent when it is realized that the desirable hydrocarbons comprise but from two to five percent of the total gaseous fluid processed. Low-temperature fractional analyses of the two representative gas-distillate reservoir fluids are presented in Table 1, for value of illustration. Case "A" is a relatively low distillate-content gas which seems to be predominantly characteristic of most high-pressure gas fields in the Gulf Coast area, while Case "B" is one of the comparatively few high-distillate-content gas fields which have been discovered.

Few phases of the petroleum industry have seen such rapid improvements as has gas recycling and distillate recovery. In fact, progress has been so rapid that several distillate recovery projects were obsolete in less than a year following completion. The more important of these processes are discussed below.

Stage Separation

As the result of 10 to 15 years of experimentation both in the field and laboratory, it has been found that



Return line for maintaining field pressure.

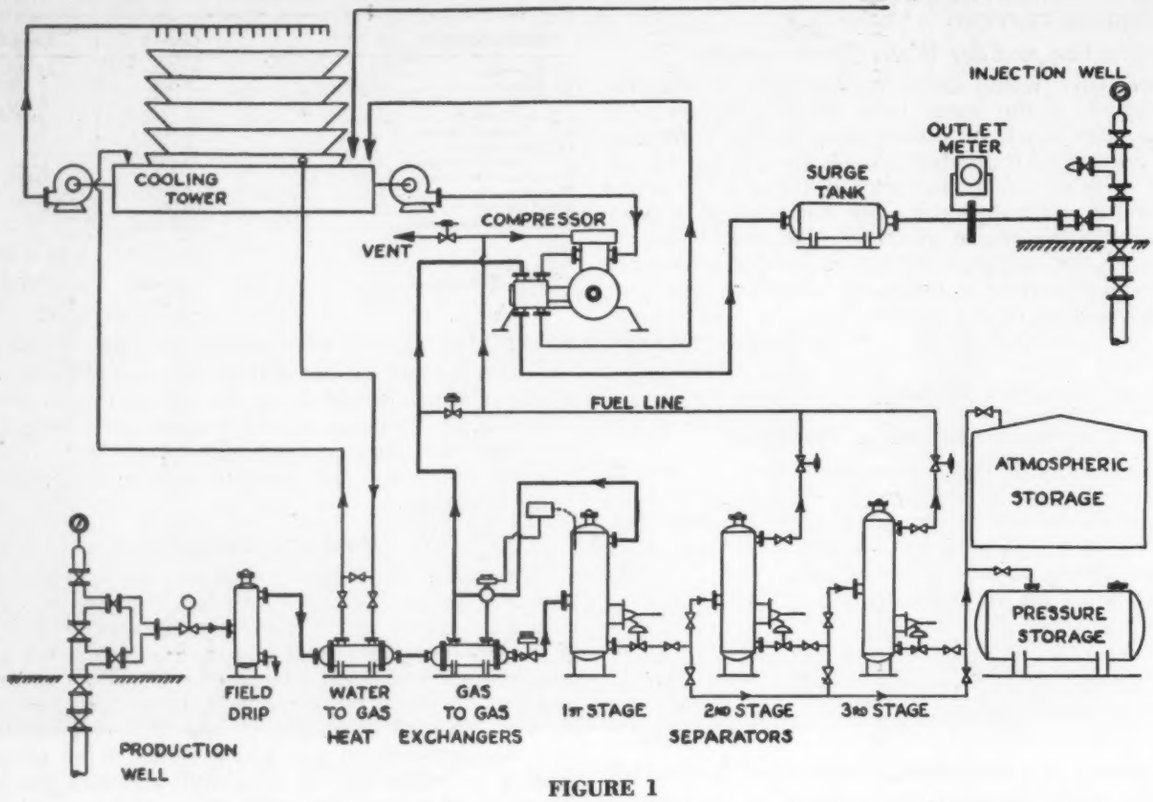
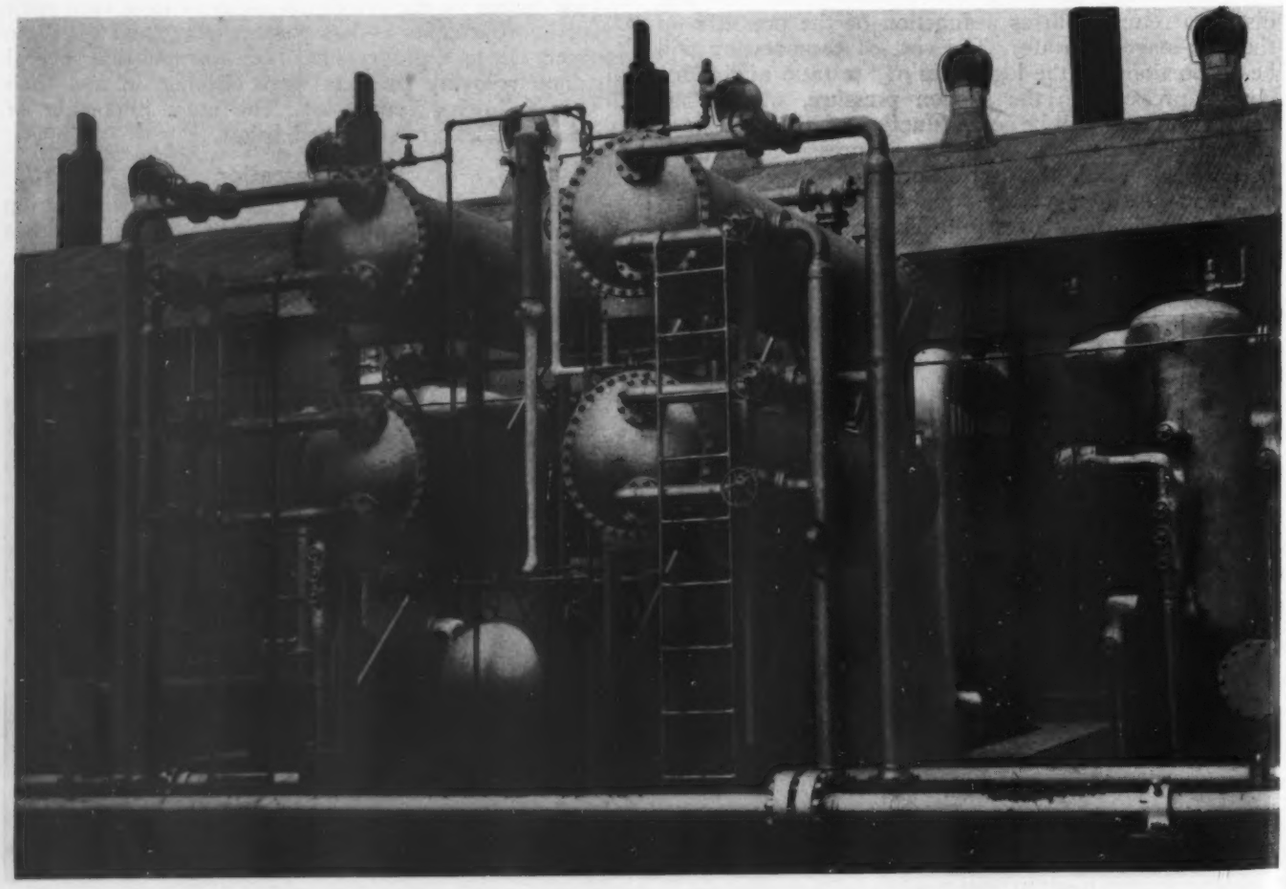
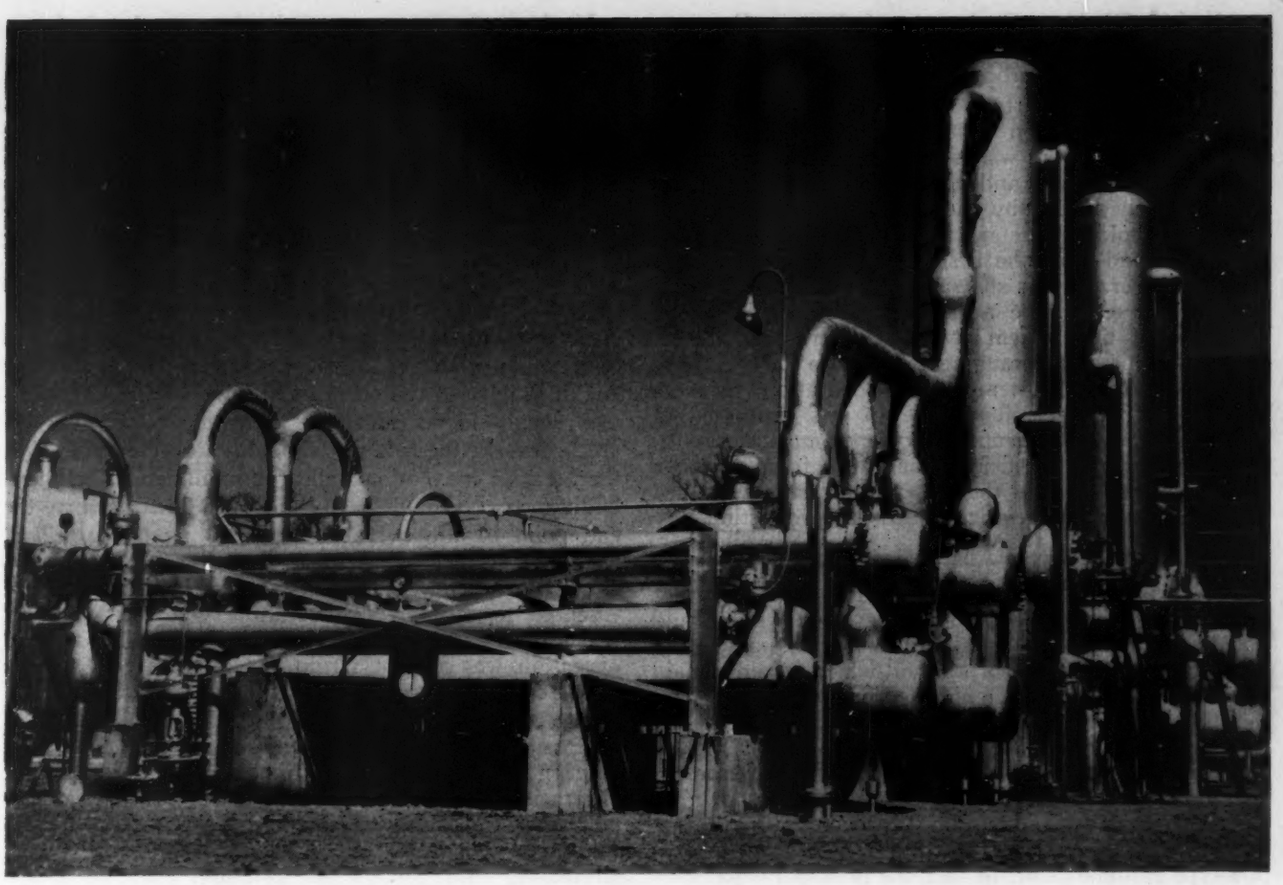


FIGURE 1

Flow diagram for pressure maintenance and condensate recovery plant.



Ammonia refrigeration unit for maintaining zero temperature in the Depco Process.



Gas-chilling unit used in temperature reduction in Depco Process.

high-gas-liquid-ratio wells respond best to several stages in which the pressure is reduced in the successive separators operating in series flow. Such an operation is a combination of flash and differential vaporization. In each stage an equilibrium flash vaporization takes place. An infinite number of stages with differential pressure drops between each two separators would represent true differential vaporization, however, three or four separations give substantialy the same result as a large number.[7, 8] In Figure 1, a conventional three-stage separator hook-up is shown with a pressure reduction ratio of 5 to 1 between successive stages, a ratio which has been found to give satisfactory results, based on both laboratory and field tests.[10]

Low Temperature Process

Recently patents covering the low-temperature-condensation process for distillate recovery have been

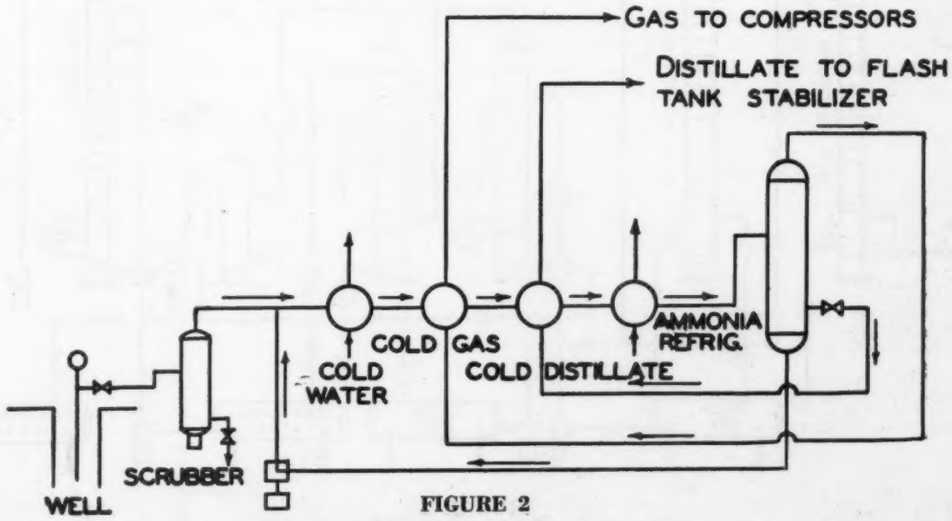


FIGURE 2

Vaughan Process for distillate recovery.

acquired by Distillate Engineering & Process Corporation. Several commercial installations have proven the effectiveness of this process.

The principal departure of this process from the simple stage-separation system, described above, lies in dehydration of the well stream by mixing with calcium chloride brine and the subsequent cooling to approximately 0° F. by means of heat exchange to cold water, cold residue gas from the first-stage separator, cold liquid from the first-stage separator, and ammonia refrigeration, as shown in Figure 2.

Extensive tests have resulted in the comparison of operation of this system at low temperatures and at nominal temperatures ranging from 60 to 75° F. These data show that low-temperature operation recovers more distillate per unit volume of gas processed at higher pressure and, hence, at lower compression cost. Such an increase in efficiency has been found to be a noteworthy advance in the art, particularly as applied to the processing of relatively lean gas production.

High Pressure Absorption Processes

For several years it was believed that an absorber operating pressure of 800 pounds per square inch could not be exceeded because it would be impossible to obtain a satisfactory absorption oil which would remain in the liquid phase at such elevated pressures. However, this theory was exploded early in 1939 by the successful operation of the Agua Dulce Corporation's plant near Banquette, Texas, at 1200 pounds pressure. A simplified flow diagram of this process is shown in Figure 3. From this illustration it is seen that the process is similar, in most respects, to a conventional absorption-type gasoline plant. In fact, the principal departures from conventional design and operation are to be found in the high-pressure absorbers and in the special absorption oil used.

Much work yet remains to be done on the performance of bubble-tray-type absorbers which are designed to operate at pressures exceeding 1000 pounds per square inch. The use of greater tray spacing, ranging upward from 36 inches, and fewer trays has shown a great deal of promise; however, the results obtained from absorbers whose trays are spaced at 24 inches seem to be giving equally good results. Needless to say, the performance of high-pressure absorber towers of various designs will be subject to close scrutiny in the future.

Choice of a satisfactory absorption oil is a problem of vital importance. It has been established that the A.P.I. gravity of the oil must be lowered and its molecular weight increased as the operating pressure is increased. Also, the cold test should be considerably lower than that of conventional absorption oil, while the initial boiling point should be substantially greater than the end point of the overhead products from the still if excessive absorption oil losses are to be avoided. Close control of the physical characteristics of the oil are essential to satisfactory operation. One particular oil which was found to be satisfactory for 1200-pound operation was a light virgin gas oil cut from a Gulf Coast crude oil, having an A.P.I. gravity of 32 and a boiling range of 425 to 650° F.

Circulation rates have been found to be remarkably low. In the vicinity of 1200 pounds pressure, efficient absorption has resulted from circulating as little as two gallons per thousand cubic feet of gas, although more satisfactory operation has been found to result from circulating four gallons per thousand cubic feet. The rate of oil circulation has been found to be quite sensitive to changes in temperature and composition of the incoming gas, necessitating close control of these variables.

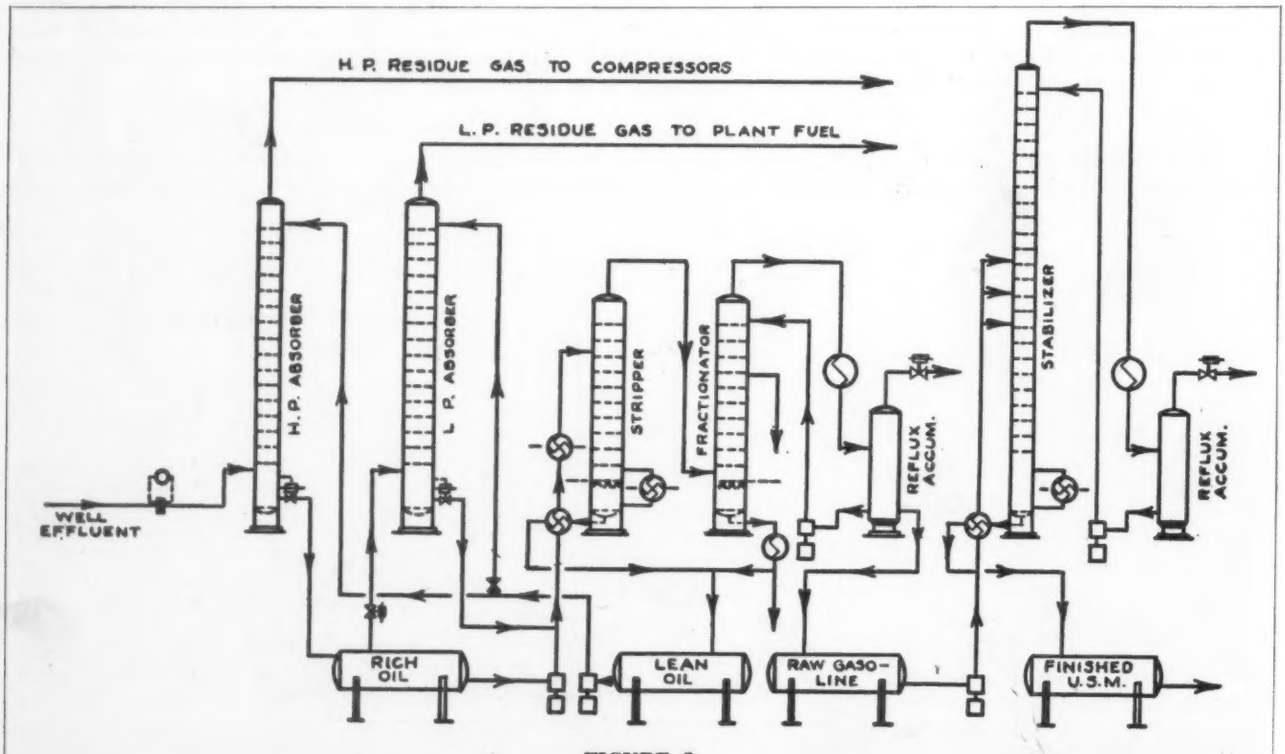


FIGURE 3
Flow diagram of absorption type distillate recovery plant.

The results obtained by high-pressure absorption-type units now in existence indicate that this process is particularly effective when operating on relatively lean gas. Furthermore, it seems likely that continued development in the field of high-pressure absorption processes will shift the basis of plant design from the condensation characteristics of the reservoir fluids to the recompression ratio required to return the residue gas to the formation, thereby resulting in higher recoveries, lower compression costs, and greater overall efficiency.[12]

Variations in Refinery Yields From Raw Distillate

Although some raw distillate is weathered to atmospheric temperature and pressure and sold on the basis of 40° API crude oil, there is a growing tendency to incorporate refining facilities into distillate-recovery systems. As a result, much raw distillate is now refined to various finished products in accordance with market demand. Of course, the inherent nature of absorption-type distillate-recovery systems make the inclusion of these facilities relatively simple; however, it is significant that the newer condensation-type installations have included fractionation and stabilization equipment.

Investigation of the physical properties of raw distillate is essential to the evaluation of gas-distillate properties and to the design of the processing equipment. For example, two gas-distillate fields exhibit a total distillate content of approximately 20 barrels per million standard cubic feet of reservoir fluid. The raw distillate from both fields would command a price equal to 40° API crude oil. However, the great variation in the physical properties are shown in Table 2, and the distillation characteristics are shown in Figure 4. Examination of these two cases reveals the fact that the reservoir pressure was 2235 pounds per square inch in the case of Sample A, and 5340 pounds per square inch in the case of Sample B.

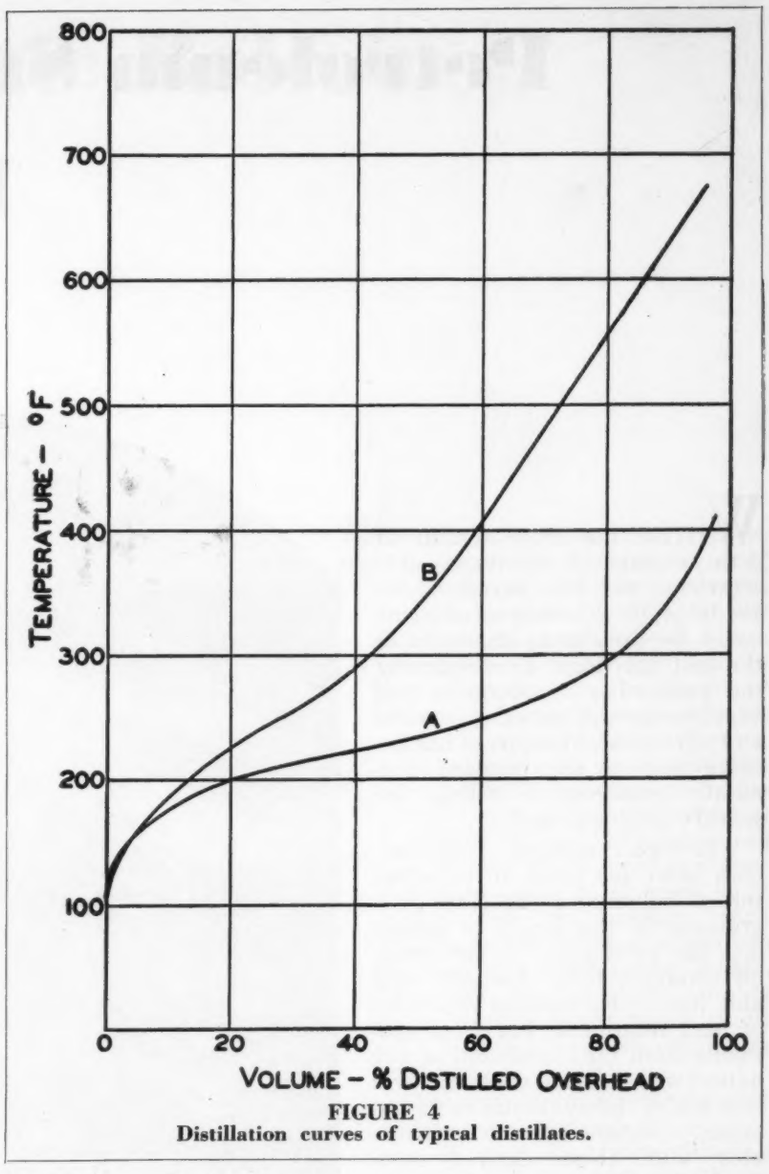


FIGURE 4
Distillation curves of typical distillates.

The physical properties of the raw distillates recovered from high-pressure gas sources are quite different in nature. These properties depend upon such variables as the source of the gas, presence or absence of a liquid hydrocarbon phase in contact with the gas in the reservoir and possibly, geological irregularities in the producing formation itself, as well as variations in reservoir pressure and temperature.

TABLE 2

	Sample A	Sample B
Gravity, API @ 60° F.	56.2	48.0
Color, Saybolt	30	30
Vapor Pressure, Reid @ 100° F., lbs.	5.2	4.8
Octane, ASTM–CFR Motor Method	70	56
Doctor	Neg.	Neg.
Distillation	°F.	°F.
IBP	123	108
5% over	157	157
10	176	189
20	198	224
30	210	255
40	221	289
50	234	335
60	248	409
70	267	488
80	295	558
90	340	630
End Point	418	675
Recovery	98	96
Residue	1	3
Loss	1	1
400 E. P. Gasoline, percent	92	64
Kerosene	7	10
Gas Oil	7	13
Bottoms	...	2
Loss	1	1

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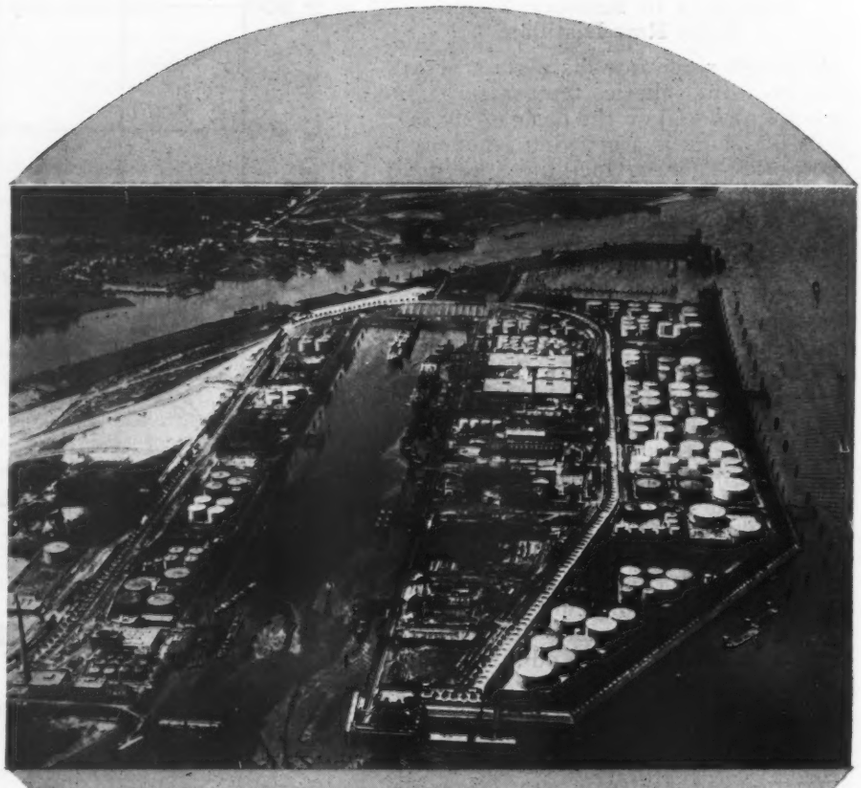
Petroleum Substitutes to Reich's War



Allied blockade control has reduced the importance of the oil port at Hamburg, once a vital factor in Germany's import trade.

WHILE not more disastrous than shortage of munitions, nevertheless, the last barrel of oil available to a beleaguered army could be almost as dramatic as the last cartridge. Consequently, the possession of adequate fuel supplies as well as other natural and agricultural resources has become one of the primary economic problems troubling the world's military staffs.

The high command of the German army has done an excellent job of influencing the Nazi government of the Reich to stimulate the production of substitute oil products from domestic coal and lignite by various processes of heat treatment. Far from economic from the standpoint of any nation with a liquid exchange and free trade, the synthetic fuels obtained compare not too unfavorably with those derived from crude petroleum.

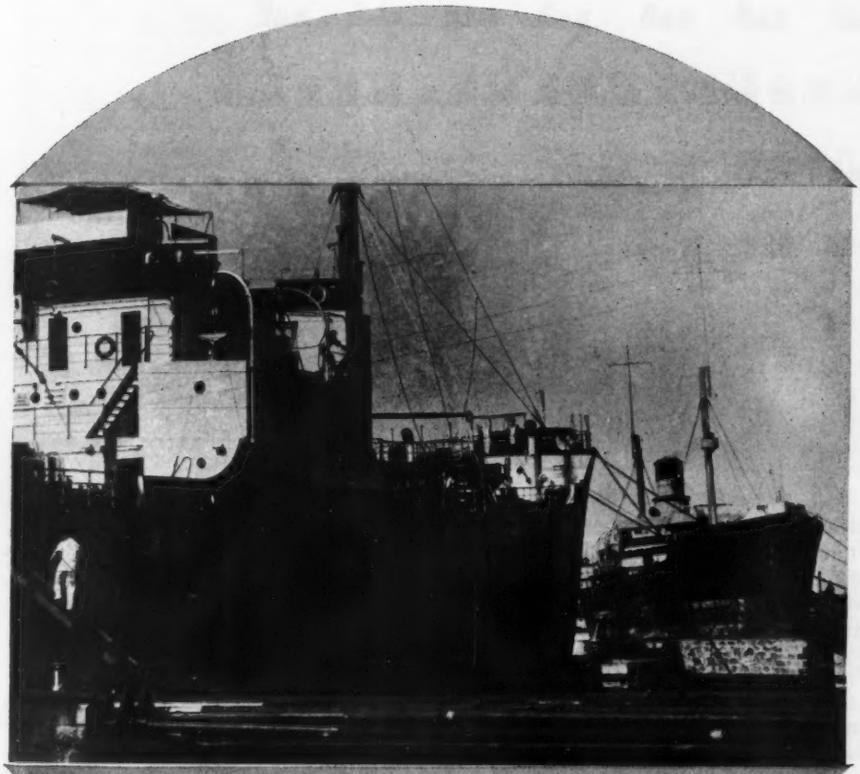
Meagre supplies of indigenous petroleum reserves made these steps necessary, which in other countries have made little or no impression due to the inherent cheapness of petroleum. Because of this purely theoretical interest, many have failed to keep track of developments in Germany and therefore consider that the extent to which petroleum substitutes are likely to play a part in the war economy of Germany is a subject in which the importance of the situation is exceeded by the interest. Strictly speaking, this is not true of Germany; uneconomic from the standpoint of the democratic states, the Reich has been building a synthetic oil industry which bids fair to equal the country's normal peace-time requirements, as well as playing a strategic role in Nazi war economy.

A number of attempts have been made to estimate both Germany's war requirements and her ability to maintain adequate supplies, and a wide diversity of opinion has been expressed. Commenting on these, the December 14, 1939 issue of *Oel und Kohle* (organ of the German oil industry) stated that in 1940 all possible requirements of the Nazi war machine will be met by the expanded synthetic oil industry. Such a reply is to be expected—but it is well to review the situation to ascertain how much truth it embodies.

Doing this, one can but come to the conclusion that while the Reich may not have as much oil as might be desired for wide-scale warfare with a highly mechanized army, nevertheless her shortage is not immediate and substitute fuels may serve to prolong the duration of the war. Another point of note is that the products obtained from coal and lignite are not all of inferior grade, and some compare in performance with petroleum oils.

Economic autarchy in the German oil industry has made great strides under Nazi stimulation, but few details of these developments have appeared in the literature in the past year or two. There has been a

Play Strategic Role in Economy



Russian tankers taking on oil at Batum, whence shipments have been made to Germany across the Black Sea, via Rumania.

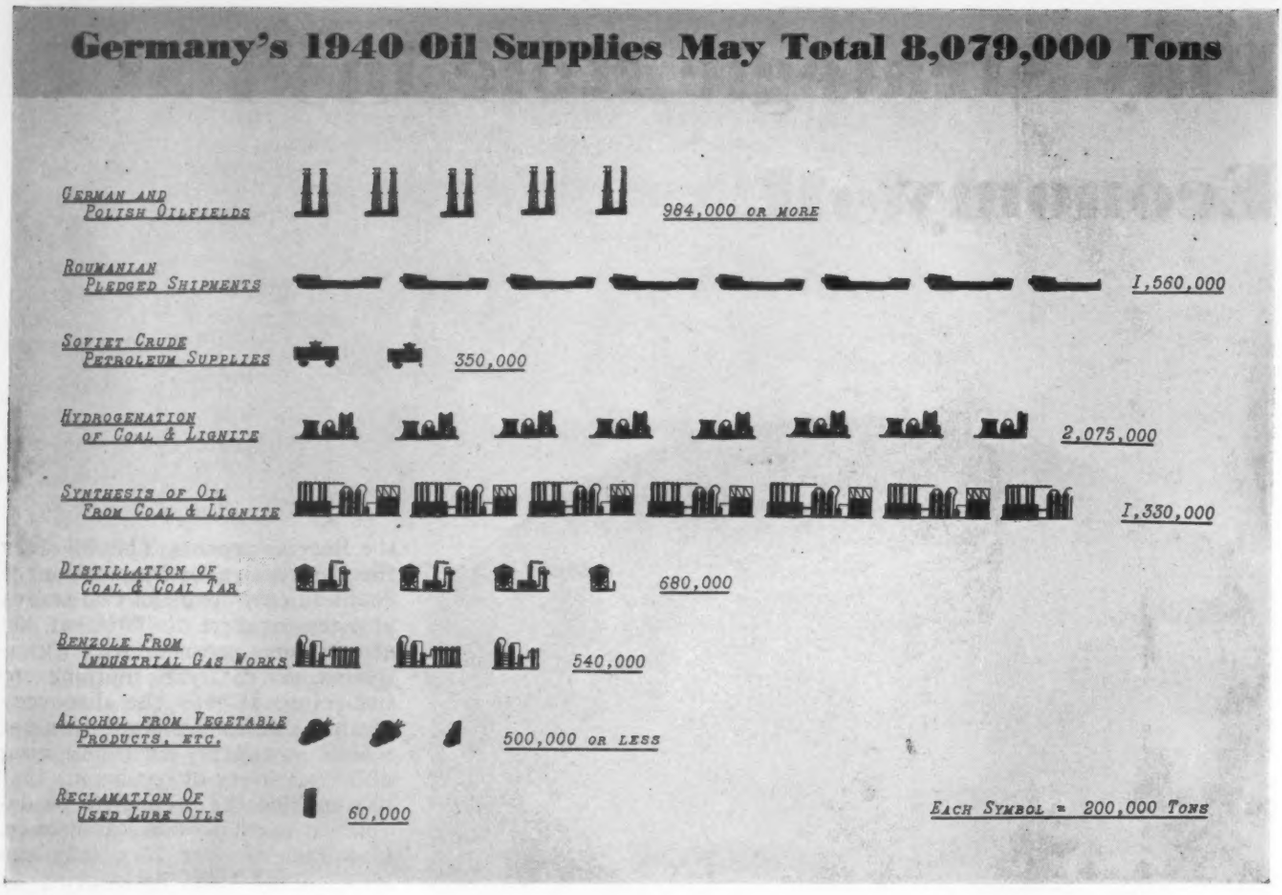
tendency in this time for the interest to shift somewhat from hydrogenation of coal to hydrocarbon synthesis, which compliments the extensive adoption of low-temperature carbonization. The Bergius process of hydrogenation appears to be employed to the exclusion of any other type, while in the field of synthesis of water gas the Fischer-Tropsch method is employed; two systems of extraction by means of phenolic solvents are in use, Pott-Broche and that of Uhde, while low-temperature carbonization employes a variety of types. The nature of the foregoing, as well as the present and potential output of each, will be discussed.

I. G. Farbenindustrie A. G., the German chemical trust, seems to have initiated the program of developing coal oils as substitutes for petroleum, employing the Bergius process. This involves the destructive hydrogenation of coal and coal-tar oil in two stages at a temperature of 400°C. at 200 atmospheres pressure with a molybdenum catalyst immune to poisoning. It was the discovery of this sulphur-resistant catalyst which is capable of functioning under a variety of conditions that has enabled the process to be developed to its present importance. Gasolines of over 75 octane can be obtained from hydrogen-poor materials, while it is possible to manufacture an aviation spirit with an unleaded rating of 85 from more suitable raw material, which, after being treated with a suitable dope, in turn might approach in performance 100-octane petroleum aero fuel.

Hydrogenation of an asphaltic middle petroleum yields a gasoline of high lead susceptibility which can be raised from 77 octane to 91.5 or 100 by addition of 0.09 or 0.20 percent tetraethyllead. However, the process is not so suitable for production of Diesel fuel due to the low cetene number.

Whatever the original vegetable deposit from which each of the rock-types is derived, "coalification" was accompanied by the loss during geologic periods of oxygen, hydrogen and some carbon, in form of water, methane and carbon dioxide, whereby a gradual concentration of carbon was effected through the stages of peat, lignite, and the range of bituminous coals to anthracite. In general, the greater the rank, the higher the reactivity toward chemical combination, and it has been noted that the low-ranking brown coals are more readily amenable to hydrogenation than bituminous coals. Germany has large reserves of this type of raw material, which is used extensively for oil production.

Hydrogenation still provides the largest volume of petroleum substitutes of the various sources, and plants under construction include one at Stettin which will be the second largest in the Reich, as



well as two in former Czechoslovakia and another in former Austria. It is believed that installations of this type have a present aggregate capacity of about 1,820,000 tons per annum, while plants still under construction should raise the total to 2,075,000 tons by the end of 1940.

Synthesis

Because of the comparatively low temperatures and pressures involved in the synthesis of oil from producer gas, construction of these plants is both cheaper and quicker, with the result that expansion has been rapid in this phase of Germany's coal-oil industry. There is one process in general use, that of Fischer-Tropsch, and capacities are usually smaller than those of hydrogenation units.

Water gas generated from coke and enriched in hydrogen so as to contain two parts of hydrogen to one part of carbon monoxide by volume, or coke-oven gas treated to give the same composition, is, after the elimination of sulphur, passed at atmospheric pressure over a catalyst of nickel-aluminum-manganese on kieselguhr a temperature of about 270°C.[1] which gives up to 72 percent of the theoretical yield of 1.4 gallons of paraffinic oils per 1000 cubic feet of synthesis gas. Other catalysts used are nickel-thorium and cobalt-thorium. Yields vary according to the temperature at which the reaction takes place, and the catalysts used, but usually amount to the following proportions of the aggregate: "Gasol" (C_3+C_4) fractions) 8 percent, "Kogasin I" (a gasoline, boiling up to 200°C.) 62 percent, "Kogasin II" (a mixture of naphtha, Diesel oil and solid paraffin wax) about 30 percent—Diesel oil from the Kogasin II fraction amounts to about 24 percent of the total products.

[1] Optimum 190°C.

Fischer-Tropsch, Percent Yield by Weight of Total Products

Fraction	1st Stage Percent	2nd Stage Percent	Total Percent
Gasol	5.0	2.0	7.0
Kogasin I	26.5	8.0	34.5
Kogasin II	26.5	11.0	37.5
Wax	—	21.0	21.0
	58.0	42.0	100.0

While hydrogenation of brown coals produces a gasoline of high anti-knock value, synthesis of lignites ordinarily yields a gasoline of low octane number. The lower the boiling point of the fraction, however, the higher the rating, so that the 30-140°C. cut rates at 62 octane (C.F.R.), and that boiling between 30-110°C. may be as high as 67 octane.

On the other hand, the Diesel oil produced has high cetene value and low specific gravity. This fraction is rated between 110-120 cetene, compared with 60-70 for Diesel fuel from petroleum and only 20-40 for oil produced by hydrogenation or from coal tar. Blends of Diesel oil from Kogasin II and coal-tar Diesel oil have proven highly satisfactory after removal of the asphaltic matter, increasing the country's potential supply of good Diesel oil.

Other valuable products are also obtainable from the Fischer-Tropsch oils: a wax of high binding power; oxidation of the paraffin wax followed by distillation, catalytic heat treatment and hydrogenation yields a product similar in characteristics to petroleum jelly; oxidation of the paraffins at 140 to 160°C. and the naphthenes at 120 to 130°C. with

or without catalysts, but requiring delicate control of the process due to the strongly exothermic nature of the reaction, produces synthetic fatty acids; and the latter in turn may be manufactured into soaps.

Probably more important, though, is the fact that the olefine constituents of the benzine produced can be converted to lubricating oils by the aluminum-chloride process. These synthetic lubricants have been constantly improved as knowledge of the reactions has increased, so that they have, in general, flat viscosity curves and are suitable for many types of automotive lubrication.

Efforts also have been made to improve the octane value of the gasolines, and T.V.P. cracking was installed at the Holten plant of Ruhrchemie A. G. with highly beneficial results. Treatment of the synthetic crude (Kogasin II) yields a gasoline of 67- to 75-octane rating; the cracked spirit requires from 3.7 to 1.3 cc. tetraethyl-lead per gallon, respectively, to raise it to 80 octane, making it very suitable for high-speed automotive engines and to a limited extent for aviation use. However, the cracked gasoline probably is used for blending purposes.

As mentioned before, the ease of installing these Fischer-Tropsch plants quickly and cheaply (they are made principally of sheet iron) will probably result in their number and capacity eventually equaling or even exceeding the hydrogenation units in Germany. At present they have a combined capacity of about 750,000 tons per annum and those building should bring the potential output to some 1,330,000 tons a year by the end of 1940.

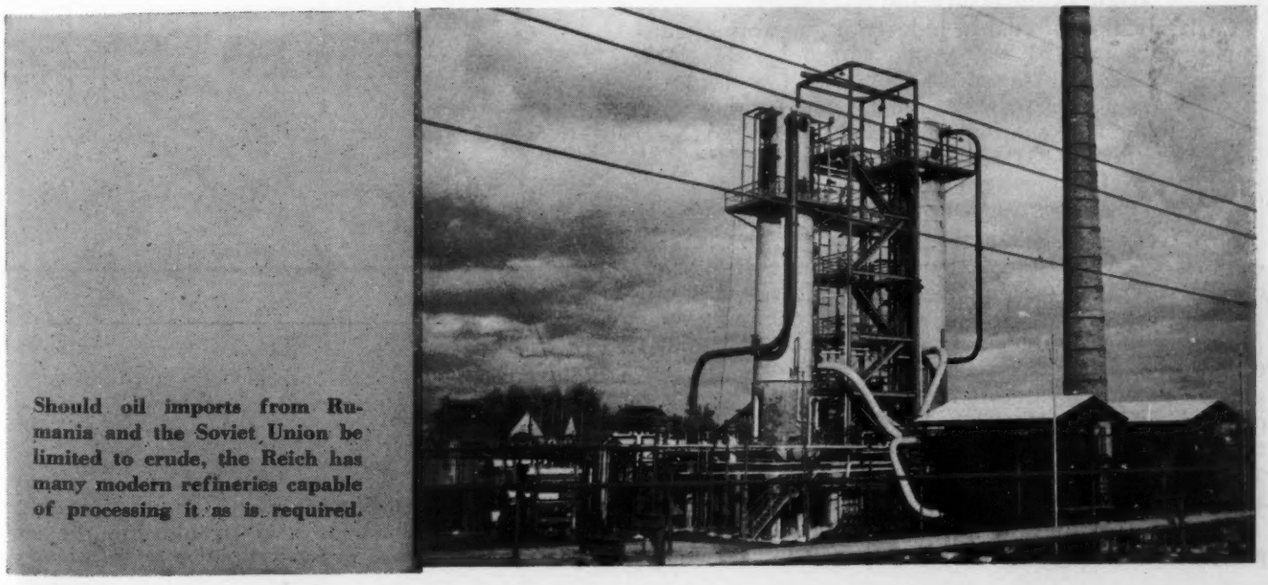
Research also has been carried out in connection with the Fischer-Pichler mean-pressure synthesis, which involves a reduction in gas throughput, combined with lower temperatures necessary, and gives an increased yield of the higher hydrocarbons: 44 percent liquid hydrocarbons, 8 percent C_3+C_4 hydrocarbons and 48 percent paraffin wax. Methane formation can be suppressed considerably, permitting almost complete conversion of the carbon monoxide and hydrogen mixture into higher hydrocarbons. However, the author has no record of any plant using the process commercially. Synthesis in the aqueous phase was carried out, but although the products were similar in quality and quantity to mean-pressure synthesis the process was not considered feasible for commercial application.

Distillation of lignite, coal and coal tar is carried out in numerous low-temperature carbonization plants all over the country, the largest of which treats 10,000 tons of brown coal daily for a yield of 700 tons of gasoline. There has been a revival in construction of these plants since 1932 because low-temperature tar is better suited to hydrogenation than solid fuel. Coal spirit yielded by low-temperature carbonization is suitable for aviation use; after the diolefine content has been removed from the straight-run lignite gasolines they sometimes have octane ratings of 86 to 92 (C.F.R.), although most distillation products average between 78 and 80 octane.

Satisfactory performance in the iron and steel industries by lube oils derived from "Urteer," (low-temperature tar) has been reported in Germany. Aside from the requirements of internal-combustion engines, turbines, steam cylinders and compressors—where petroleum lubricants with special properties are demanded—Reich technologists consider that only four oils are necessary: spindle, and light, medium and heavy bearing oils with viscosities of 2, 3.5, 4.5 and 6.5 E.° at 50°C.

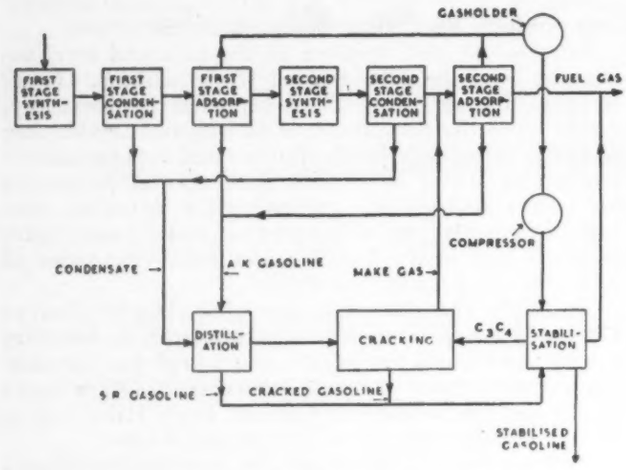
Probably the principal types of retorts used in Germany's low-temperature carbonization industry are Geissen units for lignite and Lurgi gas-circularization retorts for treating brown coal. Other types in use include Brennstoff-Technik, Berg, Hinselmann, Krupp-Lurgi, Otto, Von Haken and Koller.

Brennstoff-Technik retorts are verticle intermittent externally-heated units carbonizing at 600°C. with 4 to 6 hours heating, and may be constructed with or without collapsible walls. Berg plants process charges of coal in cages of trays, carbonization taking place at 450-500°C. Hinselmann plants are essentially tunnel-ovens in which bituminous coal is carbonized under low-temperature conditions in a series of cast iron bottomless trays travelling through gradually-rising temperatures to a maximum of 500-600°C. Krupp-Lurgi process involves vertical intermittent externally-heated steel retorts for bituminous coal so that swelling of charge results and considerable internal pressure develops. Special heat-resistant Krupp steel is used. Otto units are externally-heated intermittent vertical firebrick retorts,



Should oil imports from Rumania and the Soviet Union be limited to crude, the Reich has many modern refineries capable of processing it as is required.

rectangular in cross section and containing a series of cast-iron divisions, dividing the charge vertically and transversely into series of relatively narrow layers. The Von Haken process is used to carbonize pulverized coal at 15-18 atmospheres while Koller adopts vertical continuous retorts, heated internally by gas to about 540°C.



Flow sheet of combined Fisher and TVP Processes.

Low-temperature carbonization is not so likely to be extended appreciably in the Reich, although the products obtained are of considerable value, due to the relative cheapness and ease of constructing other types. Aggregate output of this type of coal-distillation plant, and cracking of the low-temperature tars, is about 680,000 tons per annum.

High-Temperature Carbonization

Carbonization of coal in industrial gas works is an important source of high-octane motor benzole. Although these plants yield a spirit with anti-knock rating ranging between 87 and 90 octane, they are not suitable for aviation use because of their low freezing point of —11°C. However, they are valuable for use as blending agents to raise the octane of low-grade gasolines for automotive use.

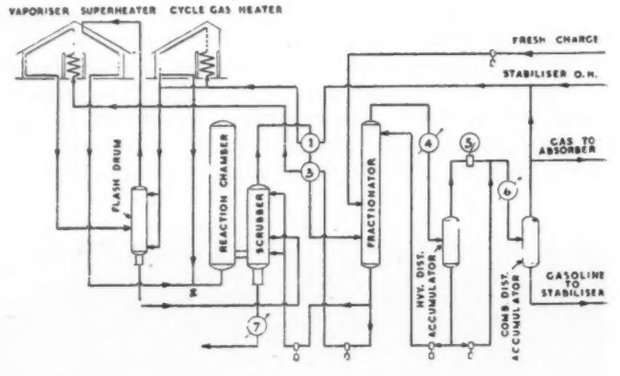
However, Dr. Benjamin T. Brooks, consulting chemist, recently stated that "an unknown number of German planes have been adapted to use benzene blends, by water cooling, thus enabling them to use some 4,500,000 barrels of benzene for aviation purposes. It also is known that some of the newer types of motors use the forced-injection method, which is also used in Diesel engines, thus enabling them to use gasoline of a wider range of octane and volatility characteristics to much greater advantage."

Be that as it may, it is possible that some of the potential annual yield of about 540,000 tons of benzole produced in Germany may be diverted to the production of toluol and explosive compounds for war use.

Extraction of a pitch-like residue from coal by a mixture such as tetralin and cresol is also carried out in Germany; hydrogenation of the extracts is said to give superior results to direct treatment of coal by the Bergius process. There are two such processes in use, that of Pott-Broche and also the Uhde extraction method, but the output of these plants is not known by the writer.

As employed at the plants of the Stinnes concern, the Pott-Broche process involves the treatment of solid fuels with suitable solvent media which boil above 100°C. in the absence of hydrogen, under pressure and temperature corresponding to the decomposition temperature of the coal material used. The crude reaction product is a homogeneous solution of coal in the solvent, with the undissolved residual and ash-enriched portion suspended in a state of finest division. This is subjected to filtration at 150-170°C. and 10-20 atmospheres excess pressure. The hot solution is twice washed with aqueous hydrochloric acid of 30 percent strength, followed by water wash. After removal of the solvent an extract of 0.02 ash content is obtained.

A variation of the extraction process employs tetraline and phenol as solvents at 300-420°C. and 10 to below 100 atmospheres in a closed vessel with hydrogen introduced during extraction, after which the extract is washed and slightly hydrogenated, using a molybdenum dioxide catalyst.



Simplified flow diagram of TVP Cracking Process.

Other Substitutes

A certain amount of alcohol and methanol are blended with the gasoline used in Germany, although not satisfactory for wide use. In addition the employment of charcoal and wood-burning "gasogenes"

(gas generators) releases an appreciable volume of motor fuel for other uses. These groups together represent about 500,000 tons per annum, but production of alcohol from beets and potatoes has been restricted as a source of motor fuel in the Reich, formerly compulsory, thus making available for human consumption a larger quantity of vegetable products.

No oil products are wasted in Germany and used lubricants are collected and regenerated on a nation-wide scale from all sumps, etc.; this source provides about 60,000 tons of lubricating oil each year.

Petroleum Production

Important though these sources of petroleum substitutes may be, they are not adequate to provide a fully balanced supply of refined products. This balance is provided to a considerable extent by the domestic output of crude petroleum from the many small oil fields within the boundaries of the Reich. The petroliferous areas of Ostmark (former Austria) have been highly developed since they were taken over by Germany, while the fields of former Czechoslovakia were capable of considerably increased yields. These added to the production developed in the Old Reich are a source of some 854,000 tons of oil per annum. Another 130,000 tons of petroleum, at the very least, are available from the Jaslo field in German-occupied Poland. According to M. W. de Piotrowski, formerly technical director of one of Poland's largest refineries at Drohobycz, several new deposits had been found between 200 and 2000 feet and that as a result of the intensive exploitation which the Germans have commenced, production can be raised by 50-70 percent. The Jaslo area was virtually unscathed during the campaign, and the refineries are adequate to take care of such increased production.

Some supplies undoubtedly will be obtained from Russian-occupied Poland, where the oil fields and refineries received great damage from both the advancing German forces and the retreating Poles, last September, while the Soviet also has been making rail shipments of petroleum from the Caucasus as well as tanker shipments through Rumania and Bulgaria, across the Black Sea. Estimate of the potential oil supplies from these Soviet-controlled sources is held to the moderate figure of 350,000 tons per year—any excess over the quantity will serve to offset possible reductions in domestic production of motor benzole and alcohol, mentioned earlier in this article.

Much more important as a source of petroleum will be Rumania, where Franco-British and German trade commissions and diplomats have been seeking to gain control of the exportable surplus for the past several months. Although King Carol's country has made certain concessions to the British, his government had long since promised to supply the Reich with 1,560,000 tons per annum and it seems likely—transportation facilities permitting—that this amount may be shipped.

Are Supplies Adequate?

On the basis of these estimates, it is evident that by the end of 1940 Germany may have an annual supply of 8,079,000 tons; the believed storage as wartime reserves at the beginning of the war was 3,000,000 tons, or more than equaling the coal-oil plants now building. This compares with an estimated wartime demand for oil put by German economists in pre-war estimates at 12,500,000 tons yearly. Other authorities have put the potential demand at figures ranging all the way up to 30,000,000 tons. These compare with a normal peacetime consumption of 6,000,000 to 8,000,000 tons.

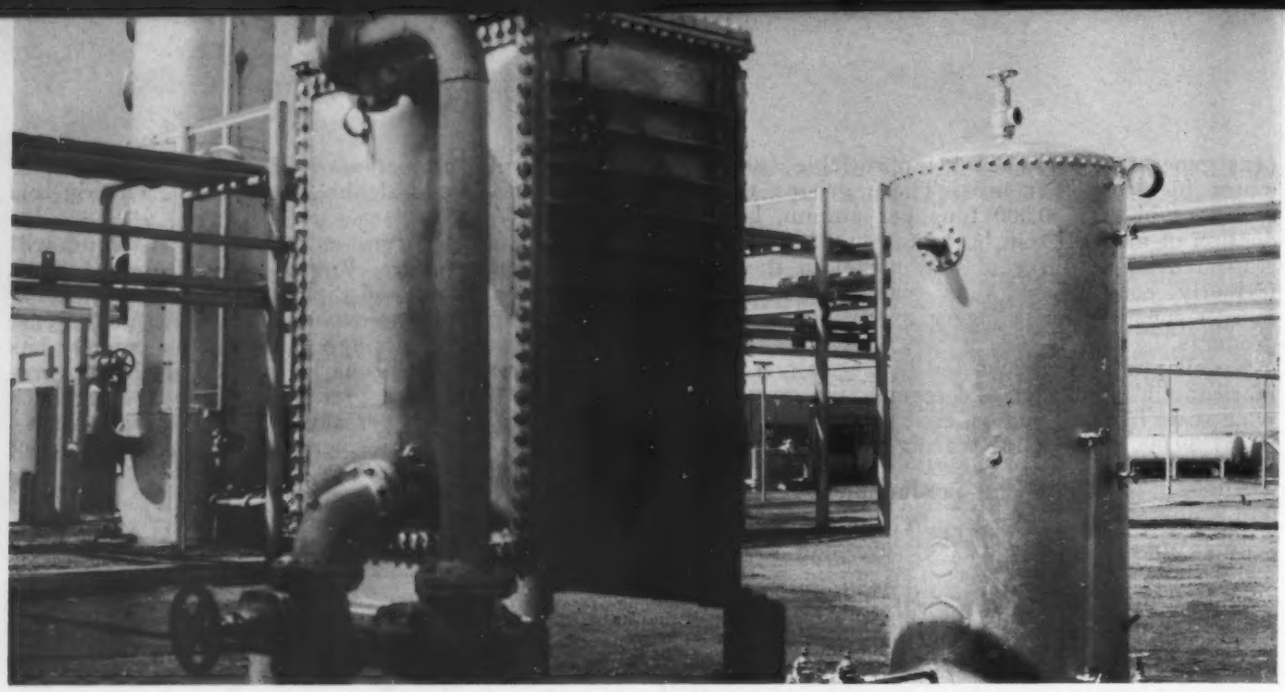
No one will deny that once the Polish campaign was ended, the Reich's oil consumption must have been held far below normal requirements.

Oil will share with food supplies the primary importance as a deciding factor in the economic blockade which is expected to determine which side will win the war. Nevertheless, one should beware of undue optimism (or pessimism, as the case may be) of Germany's early defeat through oil starvation, for World War experience has clearly shown that non-military consumption of essential raw materials can be cut down to a tenth or less of peacetime demands, and Germany may be able to survive much longer than even the foregoing somewhat favourable data might indicate.

The writer is of the opinion that the much publicized remark—"Not the guns of France or Great Britain or Poland, but the knocking of her aeroplane motors will toll the doom of Germany in this war"—was in all probability an overstatement, and feels that Nazi war plans will not be hampered for lack of petroleum supplies for some time to come.

Vomag-Lastwagen mit reinem Holzgas 25000 km.
Internationale Alpenwertungsfahrt 1934
Schwerlastzug-Betrieb · Winterwettbewerb 1935

Increased use of wood-burning gas vehicles in Germany releases additional quantities of gasoline for military purposes.



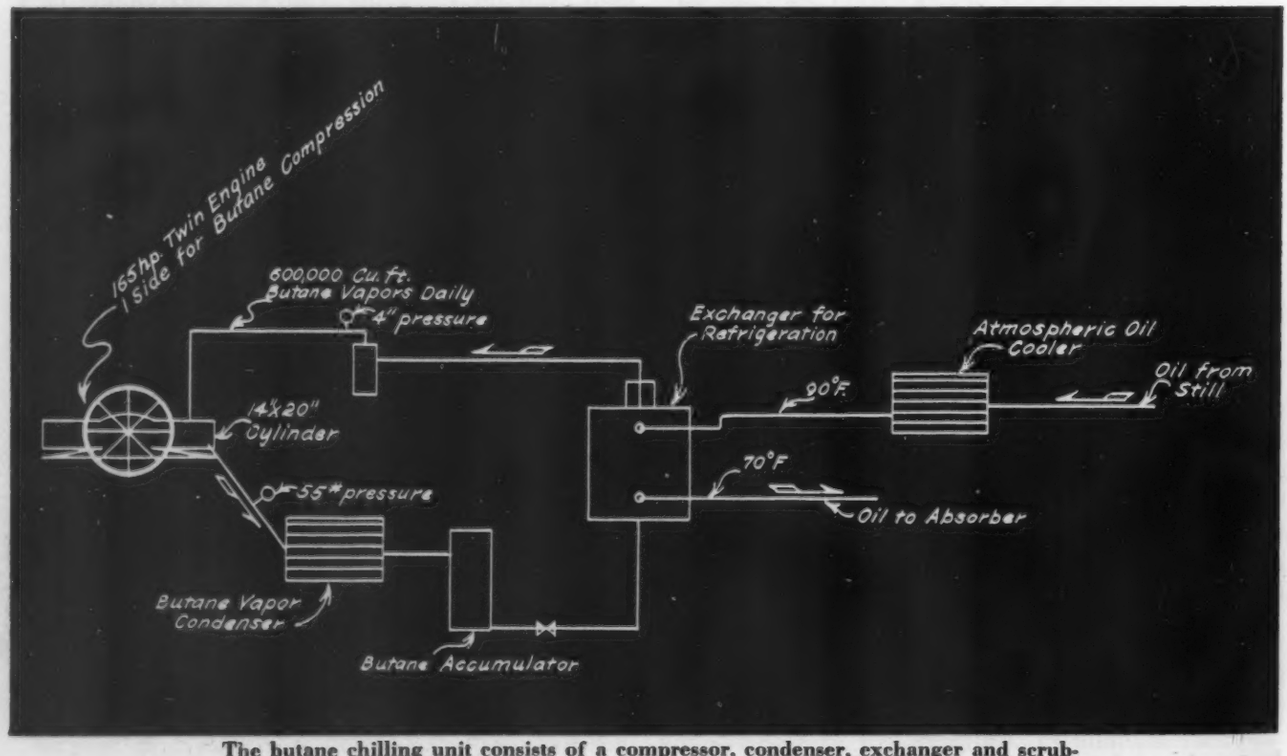
Absorption oil piping for circulation in the heat exchanger. Level of liquid butane is determined by gage glass connections.

Butane Chilling of Absorption Oil Increases Plant Yield

BY REDUCING the temperature of absorption oil 20° F. in its Fairfax plant, Skelly Oil Company has gained an increase of 2,000 gallons of natural gasoline daily. This increase does not include improved yield of butane and lighter fractions.

This temperature reduction is accomplished by expanding a normal butane cut in a closed system of shell-and-tube exchanger, through which the butane is continuously circulated. The unit requires limited equipment and occupies small space. Its operation is semi-automatic.

Previous to installation of the unit temperature



The butane chilling unit consists of a compressor, condenser, exchanger and scrubber. Absorption oil has its first temperature reduction in the atmospheric cooler.

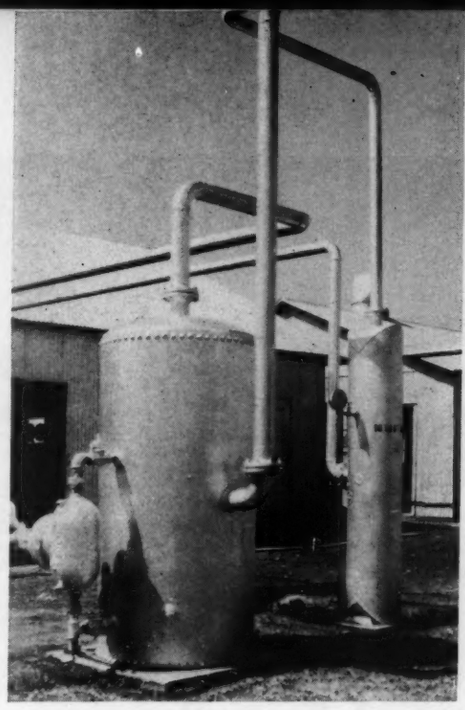
of the absorption oil averaged 90° F. during the summer. Since adoption of the refrigeration method summer temperatures have been consistently 20° F. lower.

Power to handle the butane vapors is one half the capacity of a 165-horsepower gas-engine-driven horizontal compressor. The engine is doing double duty, in that the other compressor cylinder is used to handle plant vapors for recompression. The butane cylinder has a bore of 14 inches, and a stroke of 20 inches, and operates at a discharge pressure of 55 pounds.

Water Cooling First

The flow of the butane vapors begins at the intake of the compressor at a pressure of 4 pounds, and follows through a 3-inch pipe outside the building to a discharge scrubber to trap lubricating oil that may pass from the cylinder. Continuing through the piping, the vapors are cooled and condensed in a single section of an atmospheric cooling unit, placed in the water-cooling tower. The liquefied butane is then accumulated in a small drum, installed in the plant yard near the oil-cooling equipment.

This unit is a square type exchanger, set above the ground on pipe. The inlet and outlet flanges of the shell are 4-inch, with the lower reduced to 1-inch, which is connected to the butane accumulator. Control of the flow of liquid is obtained with a lubricated plug stop, adjusted so as to maintain a required level in the accumulator so a liquid seal will remain in the vessel. The outlet for the butane is at the top with a short section of 6-inch pipe reduced to 4-inch for the vapors to return to the compressor. In the line between the exchanger and the compressor, is a vapor scrubber equipped with a float case which actuates a mercury switch if and when liquids enter the scrubber in sufficient quantities to begin filling the vessel. This is a safety appliance, designed to short the magneto to prevent damage to the engine if liquids are in danger of being admitted to the cylinder.



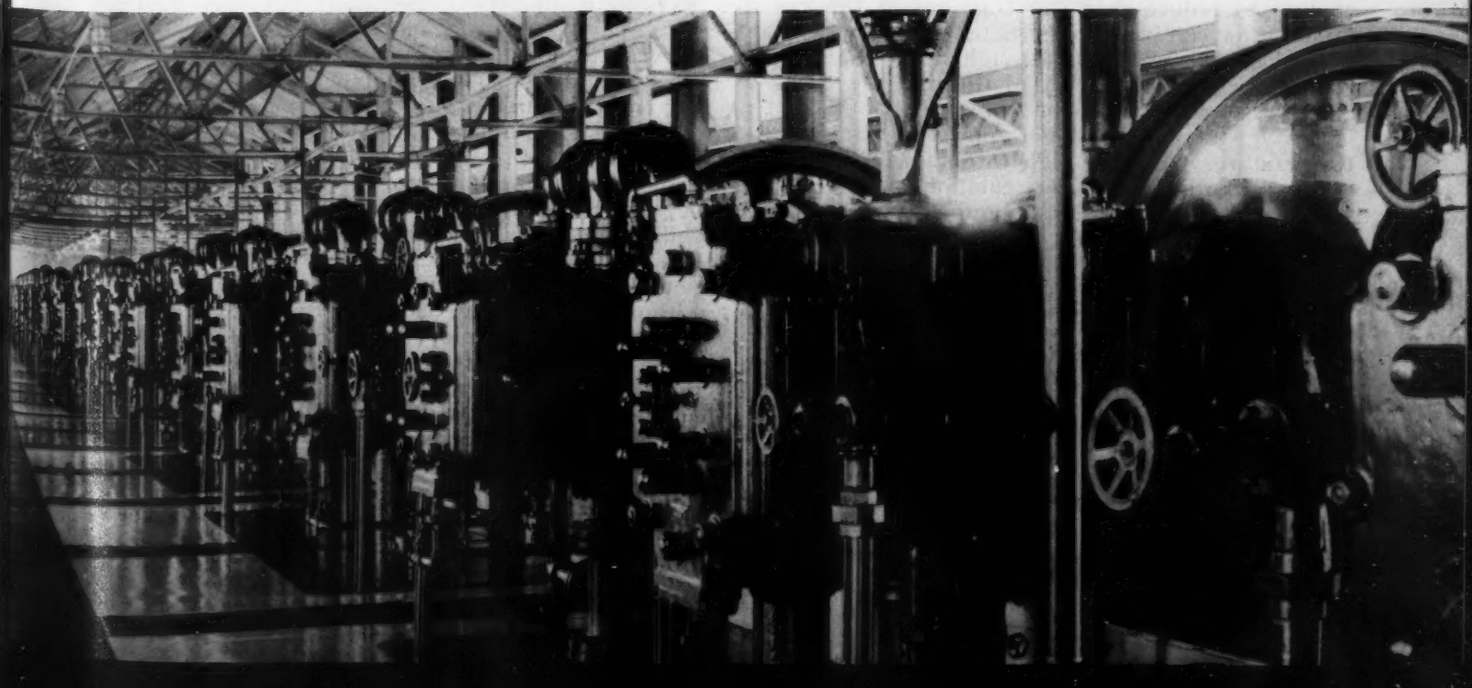
Intake and discharge scrubber in the butane refrigeration circuit.

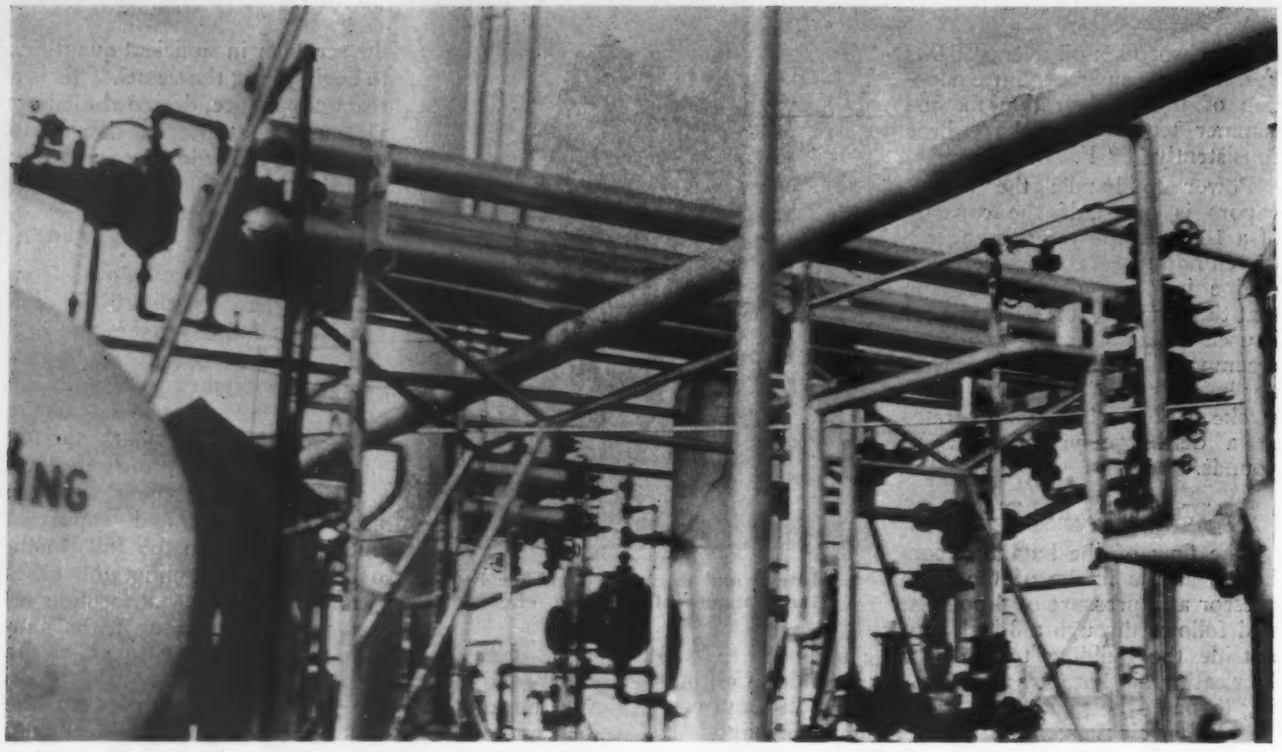
Tubes Partly Submerged

The absorption oil flows from the absorber to the distillation equipment and the exchangers and coolers. After temperature reduction in the cooling tower, the oil travels to the exchanger in the butane circuit. Entering at the top flanged connection, the oil flows downward, counter current to the ascending liquid and vaporized butane. To obtain the full benefit of the butane cooling, the tubes through which the absorption oil flows are about four fifths submerged with butane liquid, following closely the flooded refrigeration systems used in refineries when dewaxing oils. Gauge glasses are installed in the upper part of the exchanger so the fluid level may be checked occasionally. If the level raises higher than deemed necessary for adequate flooding of the tubes, the lubricated plug valve is adjusted to correct the flow. It has been observed, however, that, as the operation of the butane system is constant, the level in the accumulator and the exchanger remains constant also.

The absorption oil is of a type ordinarily used in gasoline plants, and has an A. P. I. gravity of 37-38. The volume required by the Fairfax plant is about 240,000 gallons per day. The amount of butane vapors handled by the compressor to obtain the 20° drop in temperature is 600,000 cubic feet daily, registered by a recording flow meter on the compressor intake piping.

One engine of the compressor station is used for handling butane in the refrigeration circuit as well as for recompression of plant vapors.





By liquid level control the shell-and-tube chiller is maintained one third full. The inlet control valve is near the inlet connection so expansion takes place largely within the shell.

Butane-Propane Mixture Used in Temperature Reduction

SINCE butane has been adopted as fuel for drilling in North Texas, methods have been applied to gasoline plants to increase its yield. Deep Oil Development Company is using a mixture of butane and propane to reduce the temperature of intermediate pressure gas.

As in other plants employing compression and cooling to reduce desirable fractions in the gas to liquid, this company constructed its K-M-A plant with shell-and-tube units through which the gas was passed with water circulated through the tubes to obtain the required temperature.

During the past summer, however, atmospheric temperatures were too high to obtain low temperatures with ordinary water circulation, and steps were taken to employ expansion of liquified gases to reduce the temperatures further. Until that time, the value of propane and butane as separate commodities, or as a blend in varying proportions, was not high, and the gasoline was reduced to 12 or 14 pounds Reid vapor pressure.

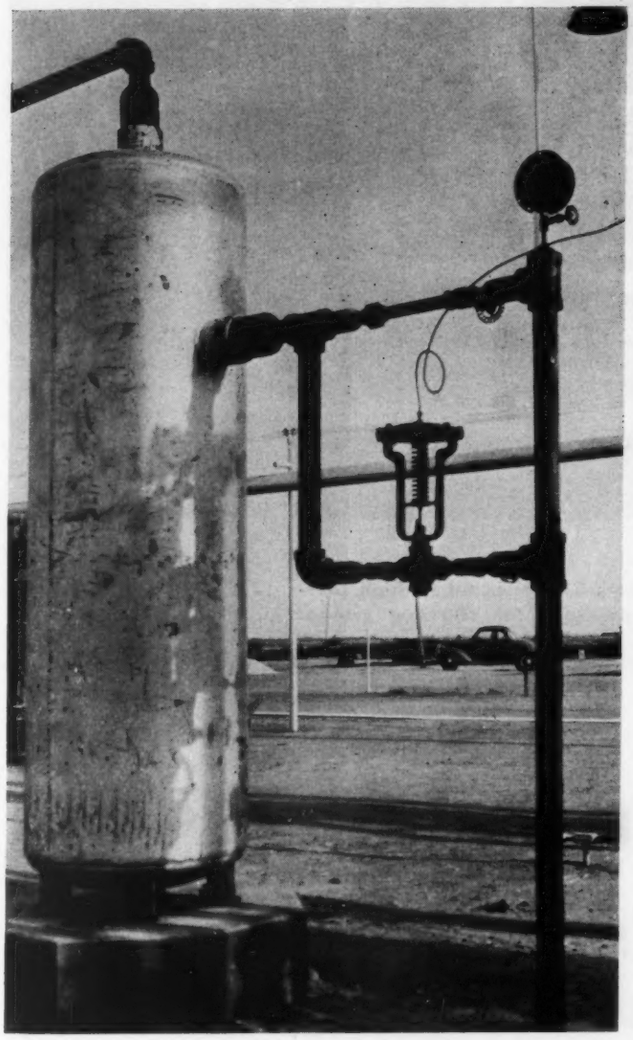
When the process which utilized the lighter fractions as the cooling medium was considered, a shell-and-tube unit was built so that the gas in the second stage of compression might be passed from the water-cooled units through the new part of the plant for further reduction of temperature. This cooler consists of a 20-inch shell 10 feet long, having a welded head at the rear and a flanged head at the front. Hair-pin tubes, ½-inch in diameter, rolled into a tube sheet filled the shell. The tube sheet was welded to the interior of the shell, permitting expansion and contraction to take place in the floating tubes. The tube sheet was planed flat with enough clearance between it and the bolted head cover so a single strip of gasket material is used as the dividing line between the inlet and outlet of the gases. Nipples in the bolted cover admits piping for travel of gas to and from the unit itself.

As the shell-and-tube gas coolers originally installed in this plant were placed on a steel support high above the accumulators and scrubbers the space between two banks was sufficiently large that the chilling section could be installed between them. By-pass connections between the water-cooled sections and the chiller unit permit operation with or without refrigeration, as necessity dictates.

The material employed for refrigeration is a cut taken from the plant stabilizer overhead, or from the second or fourth plate from the top, depending upon the composition desired. If from the overhead, the condensate consists essentially of propane, and if from the second plate, a preponderance of propane is included. But if the cut is taken from the fourth

plate, the material contains more butanes than any other fraction. The commodity is withdrawn and the system filled with about 275 gallons of liquid, most of which rests in the chiller and supply accumulator until the circulation is started.

An 80-horsepower horizontal gas engine with a 6¼- by 20-inch compressor cylinder handles the refrigerant. This small cylinder was selected because it can be used, if required, to return dry gas to the oil-producing formation in the repressuring campaign now beginning in the district. Pressures of from 65 to 70 pounds are set for the discharge of the gas,

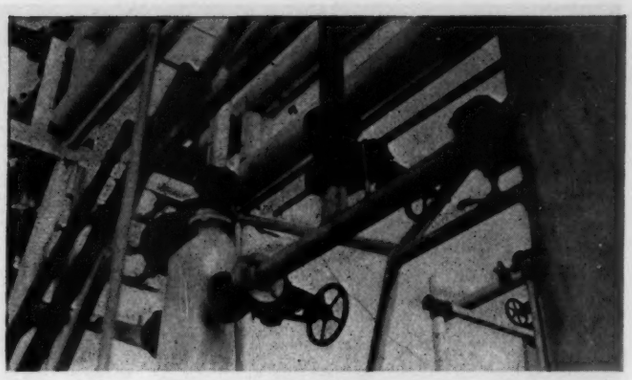


Pressure on the shell-and-tube chiller is controlled by a diaphragm valve on the vapor outlet of the diaphragm gas cooler. An automatic instrument in the control room is set for predetermined pressure control.

which flows from the engine to atmospheric sections in a water-cooling tower, and from that unit to a small horizontal accumulator near the chiller. This accumulator is used only as a reserve tank for the liquid, and has the usual type of inlet and outlet connections.

Pressure Control

The fluid flows from the reserve accumulator to the elevated shell-and-tube chiller, controlled by a diaphragm valve actuated by a float gage on the end of the unit so that approximately a third of the shell is filled with liquid, with the hair-pin tubes in the



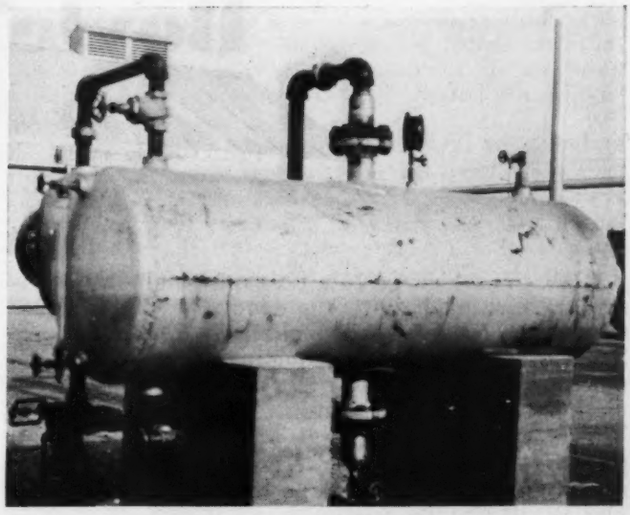
A by-pass unit between the water cooled section and the chiller permits plant operation with or without refrigeration.

liquid being the outlet section so that the gas receives its chilling in partially submerged tubes. The liquid-inlet-control valve is close to the inlet connection so that expansion of the material is largely within the shell.

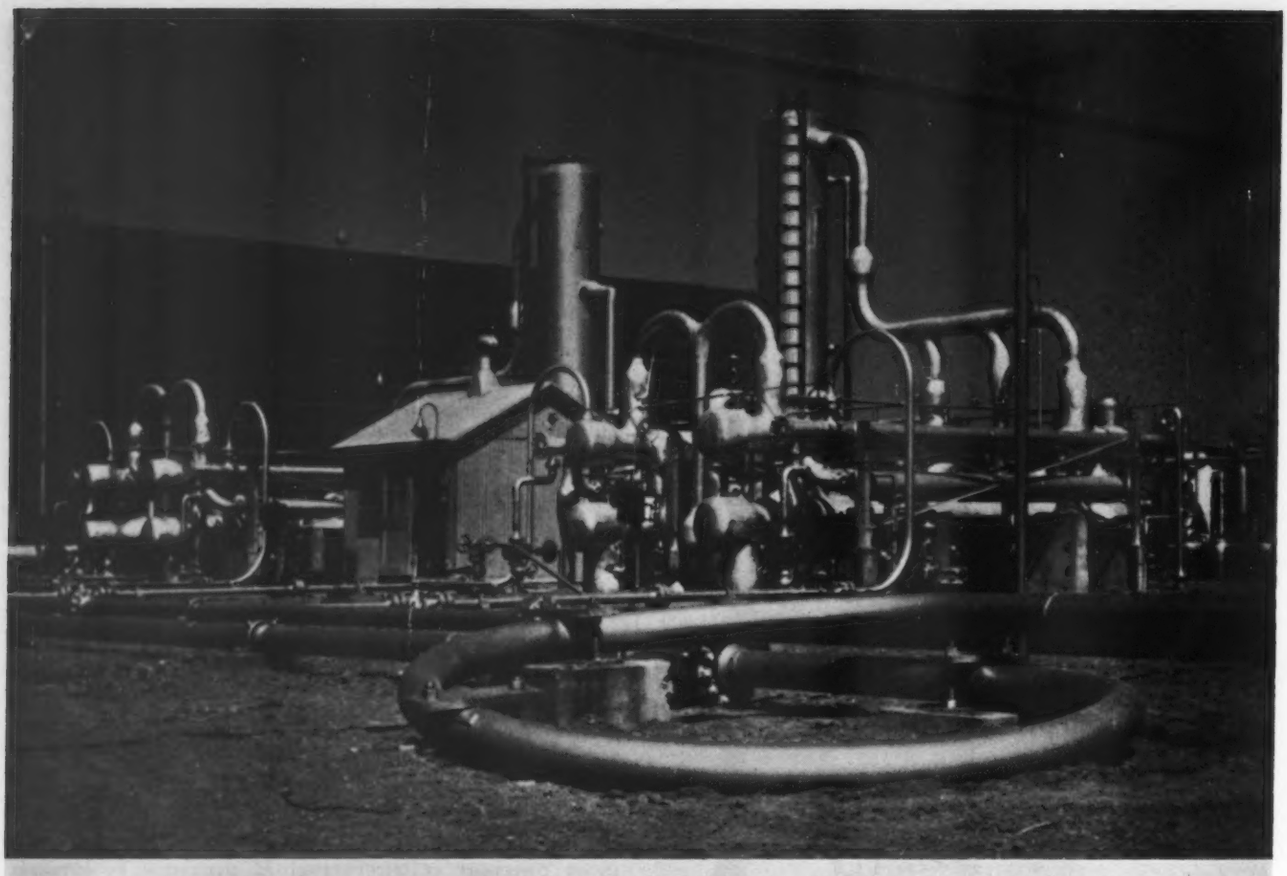
The pressure within the shell-and-tube chiller is controlled by a diaphragm valve some distance from the elevated unit, installed on a scrubber to prevent liquids from passing from the chilling section to the inlet header of the compressor cylinder. An automatic instrument in the control room, which may be set at any predetermined pressure, maintains the required back pressure on the chilling unit.

Since the unit has been in operation, about 15 pounds back pressure has been found sufficient for most efficient refrigeration. If pressure is lowered to between 5 and 10 pounds, gauge, freezing occurs within the chiller, which prevents adequate refrigeration, due to plugging lines and instruments.

Production of pentane and heavier fractions has not been increased appreciably, because these are liquefied under the usual operating conditions, but production of the butanes and propane has been increased. The reduction of water vapor and condensed water has been accomplished so that the pressure-reducing valves on the injection wells within that part of the repressuring project maintained by Deep Oil Development Company become inoperative less frequently than under former operating procedure.



The accumulator on the liquid side of the chilling and condensing system is used for a reserve tank of butane-propane mixture.



Abnormal behavior of heavier hydrocarbon gases under high pressure and temperature is partly responsible for recycling growth.

Deviation of Natural Gas From Boyle's Law

By FRANK H. DOTTERWEICH
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ANY gas which gives a pressure-volume relationship in agreement with the fundamental gas equation $PV = NRT$ is called an ideal or perfect gas. Some gases approach the qualities of a perfect gas more so than others, but in all cases there is a deviation from the relationship that $PV =$ a constant. This deviation becomes more pronounced at low temperatures and high pressures, and for gas measurement under such conditions the equation of Van Der Waal[1] may be used.

As previously stated, at normal conditions of temperature and pressure, Boyle's law may be used without the introduction of appreciable error. With increasing pressures, correction factors must be applied if gas measurements are to be satisfactory. Some gases are not compressed as much as Boyle's law indicates at high pressures; other gases occupy a smaller volume than this law would indicate, and in this classification natural gas is included.

When a given volume of methane, measured at a base pressure and temperature, is compressed, Hamline, Kvalines and Gaddy[2] have shown that as the pressure is increased, Figure 1, up to 150 atmospheres the gas is supercompressible. Supercompressibility

may be defined as being compressed to a smaller volume than would be predicted by Boyle's law. As the pressure is increased above 150 atmospheres the deviation decreases until a pressure of between 300 and 350 atmospheres is attained, dependent upon temperature, at which pressure the gas once again conforms to Boyle's law. Increased compression of the gas results in the gas occupying a greater volume than would be calculated from Boyle's law.

In general field operations, under 50 atmospheres pressure, gas is measured at high pressures and the measured volume will be less due to the supercompressibility. As this gas expands to a low pressure, it will then exhibit the phenomena of supercompressibility. This factor for conditions, under 350 atmospheres pressure, will be greater than one, and above this pressure less than one as in the case of methane at 122° F., Figure 1.

By reference to Figure 1, it may be noted that temperature also affects these factors. In the case of methane, increased temperature results in decreased deviation. Therefore, when natural gas is measured at high pressure the measured volume must be corrected by a deviation factor, dependent upon the composition of the gas and the pressure and temperature at which this measurement is made. This deviation factor may be obtained from tables and charts prepared by the United States Bureau of Standards[3] or it may be calculated if the composition of the gas is known.

Diehl[4] has taken the deviation factors of various gas as given in the Bureau of Mines Technical Paper 158, and developed the following satisfactory formula:

$$N = \frac{0.154\ p\ (m + 4e + 3c + 0.22a)}{1000}$$

in which:

N = deviation in percent
p = pressure in pounds per square inch gauge
m = percent methane
e = percent ethane
c = percent carbon dioxide
a = percent air

The American Gas Association Measurement Committee suggest that the gas volume obtained from flow measurements at high pressure be multiplied by a correction factor = the square root of $1 + \frac{N}{100}$ where N is the percent deviation. Should the measurement at high pressures be made by displacement meters the observed volume should be multiplied by a correction factor $1 + \frac{N}{100}$ in which N is also the percent deviation as obtained by Diehl's formula. However for the use of this formulae, and the conversion of the deviation factor, the reader is referred to "Natural Gas Handbook" by Diehl which also contains many helpful tables relative to this problem.

The abnormal behavior of heavier hydrocarbon gases under exceedingly high pressure and temperature introduces a relatively new phenomena of so-called "retrograde condensation." This new phenomena is partly responsible for the growth in recycling and repressuring projects.

The economics of recycling or repressuring projects is governed in general, by the cost of recompressing the condition gas, as in the case of recycling, and returning it to the formation.

These costs of operation are determined by the amount of power required. Three factors govern in general the horsepower required to compress the gas; they are as follows:

1. Volume of gas to be handled.
2. Suction pressure to the compressor.
3. Discharge pressure of the compressor.

It will be noted that the volume of gas compressed is of importance in the design and operation of compressors in recycling and repressuring work.

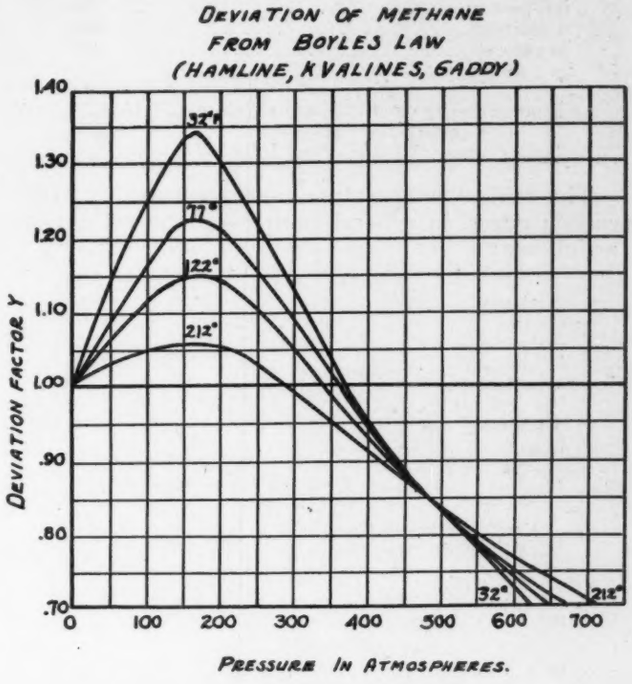


FIGURE 1

As previously stated the deviation factor may be calculated from tables and formulae set forth in Diehl.[4] With the high pressures encountered in recycling operations, other methods for calculating this deviation factor have been investigated as the effect of deviation from the gas laws on compressor capacity has important relations.

Various methods for estimating the amount of deviation at high pressures, above 30 atmospheres are available, but the lack of actual deviation measurements may in part be attributed to the fact that the design of compression equipment in recycling work, by test procedure, has eliminated the importance of such calculations.

One method of general importance, to calculate the deviation factor from the perfect gas laws is that suggested by Cope, Lewis, and Weber[5] and Lewis and Luke.[6] This method is based on the laws of corresponding states. These investigators found that by the use of reduced critical conditions the properties of hydrocarbon gases over a wide range of conditions could be estimated.

Their generalized curve based on available data is shown in Figure 2, however, to utilize this curve, it is necessary to know the critical pressure and temperature of the gas. In the absence of data on the critical mixtures of hydrocarbon vapors, Kay[7] has found that the properties can be estimated by a method in which he makes use of pseudocritical relationship.

To illustrate this method of calculating the devia-

tion factor, let it be assumed that the gas analysis line pressure and temperature is as follows:

EXAMPLE
Analysis of Gas

Constituent	Mol Fraction
methane	.850
ethane	.088
propane	.034
iso-butane	.009
n-butane	.010
iso-pentane	.004
n-pentane	.002
hexane + as heptane	.003
	1.000

Line pressure = 1630 pounds gauge or 1644.7 pounds per square inch absolute
Temperature = 70.0° F. or 530.0° Rankine

The critical temperatures and pressures of hydrocarbon gases, in general composing natural gas, are as follows:

	T_c	P_c
methane	344	673
ethane	549	717
propane	667	617
iso-butane	732	544
n-butane	766	545
iso-pentane	829	483
n-pentane	846	485
hexane + as heptane	972	397

where T_c = critical temperature
P_c = critical pressure
Pseudo temperature = $T_c \times$ Mol Fraction
Pseudo pressure = $P_c \times$ Mol Fraction

With the gas analysis available in percent by volume this figure is also the mol fraction of the respective constituent in the gas. Therefore the respective pseudo temperature is equal to the mol fraction or percent by volume of each constituent times the respective critical temperature or pressure. The results are as follows:

	Pseudo temp.	Pseudo pres.
methane	292.4	572.0
ethane	48.3	63.1
propane	22.7	21.0
iso-butane	6.6	4.9
n-butane	7.7	5.5
iso-pentane	3.3	1.9
n-pentane	1.7	1.0
hexane + as heptane	2.9	1.2
	385.6 deg. Rankine	670.6 lbs. per sq. in. abs.

Having calculated pseudo temperature and pressure, the reduced pseudo temperature and pressure may be obtained as:

T_r = Pseudo Reduced Temperature

$$T_r = \frac{\text{Line Temperature}}{\text{Pseudo Temperature}}$$

$$T_r = \frac{530.0}{385.6} = 1.377$$

P_r = Pseudo Reduced Pressure

$$P_r = \frac{\text{Line Pressure}}{\text{Pseudo Pressure}}$$

$$P_r = \frac{1644.7}{670.6} = 2.45$$

With values of P_r and T_r known by reference to Figure 2, it will be observed that the compressibility

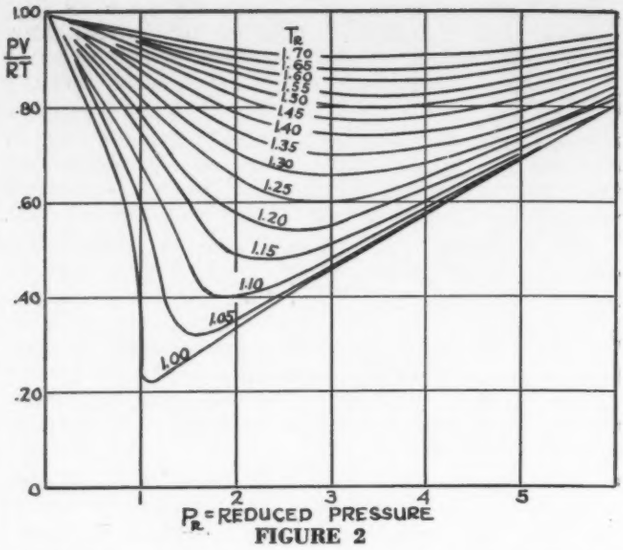


FIGURE 2

factor or ratio of actual to theoretical volume will be .71,

$$\text{or } \frac{PV}{RT} = .71$$

This figure suggests that the observed volume will only be 71 percent of the actual volume when the gas is referred to standard conditions of pressure and temperature. If the measurements are made by flow instruments, the following method of obtaining the factor F_{pv} is recommended:

Application to Metering (Flow Instruments)

F_{pv} = Super Compressibility Factor

$$F_{pv} = \sqrt{1 + N}$$

Where
N = deviation multiplied by 100 percent deviation from Boyle's Law

$$N = \frac{\frac{100}{(PV)} - 100}{\frac{(RT)}{100}} = \frac{100 - 100}{\frac{.71}{100}} = .41$$

$$F_{pv} = \sqrt{1 + .41}$$

$$F_{pv} = \sqrt{1.41}$$

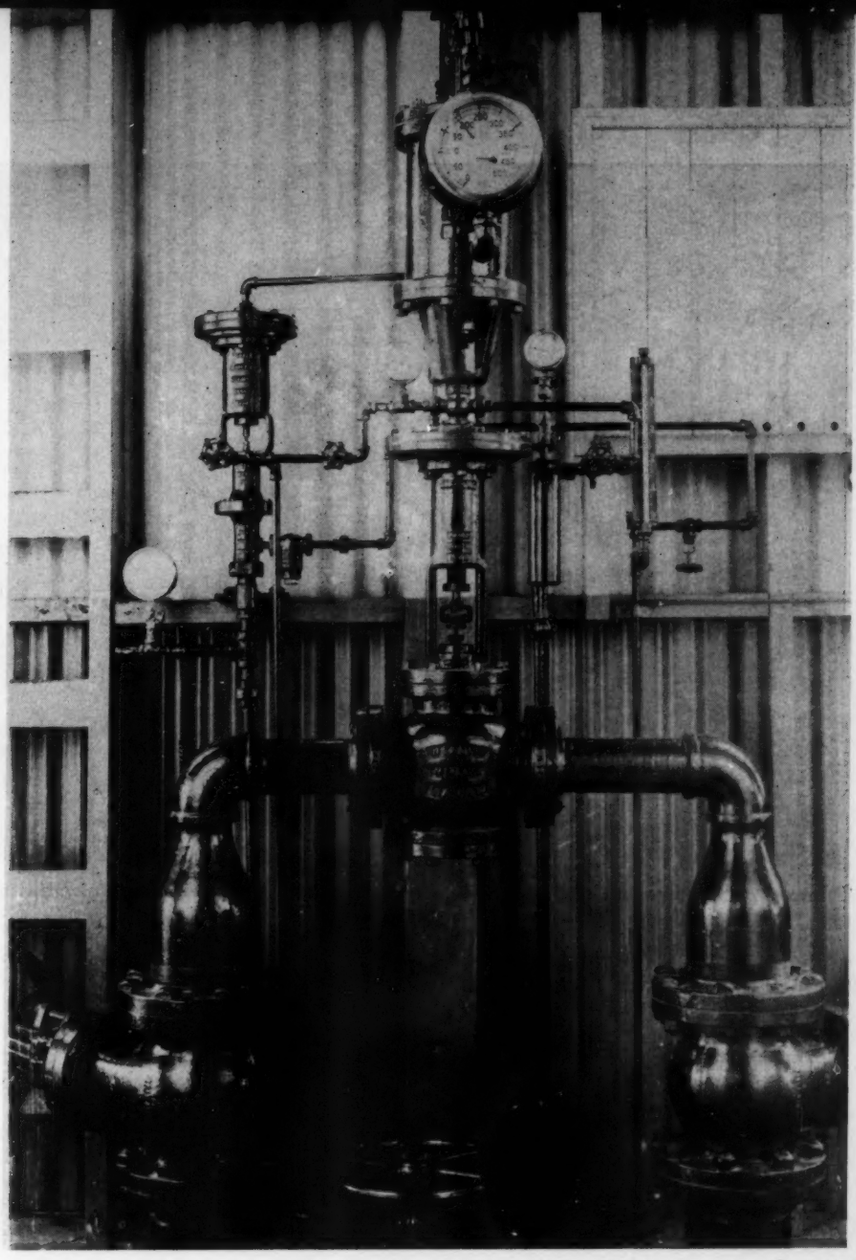
$$F_{pv} = 1.19$$

Therefore the volume as obtained from a flow meter must be multiplied by 1.19 to obtain the correct volume. Should displacement methods of measurement have been used this factor would have been 1.41.

Laverty[8] has produced calculations to show that this method of calculating the deviation factor at high pressure and temperatures gives results in agreement as to the method, as proposed by Kvalnes and Gaddy[9]; however, it must be noted that these methods give results in error when applied to the two-phase region where gas and liquid are present. Methods of deviation calculations in the two-phase system at the present time have not been developed to the point of satisfactory practical application.

References

[1] Getman and Daniels, **Outlines of Theoretical Chemistry.**
[2] Hamline, Kvalnes, and Gaddy, **Journal of American Chemical Society,** page 394, February, 1931.
[3] U. S. Bureau of Standards, Circular No. 279.
U. S. Bureau of Standards, Miscellaneous Pub. No. 71.
[4] Diehl, John C., **Natural Gas Handbook,** page 201.
[5] Cope, Lewis and Weber, **Industrial and Engineering,** Volume 23, August, 1931.
[6] Lewis and Luke, **Industrial and Engineering Chemistry,** 25, 725, (1933).
[7] Kay, W. B., **Industrial and Engineering Chemistry,** 28, 1014 (1936).
[8] Laverty, F. W., **Oil and Gas Journal,** November 2, 1939.
[9] Kvalnes and Gaddy, **Journal of American Chemical Society,** Volume 53, 394 (1931).



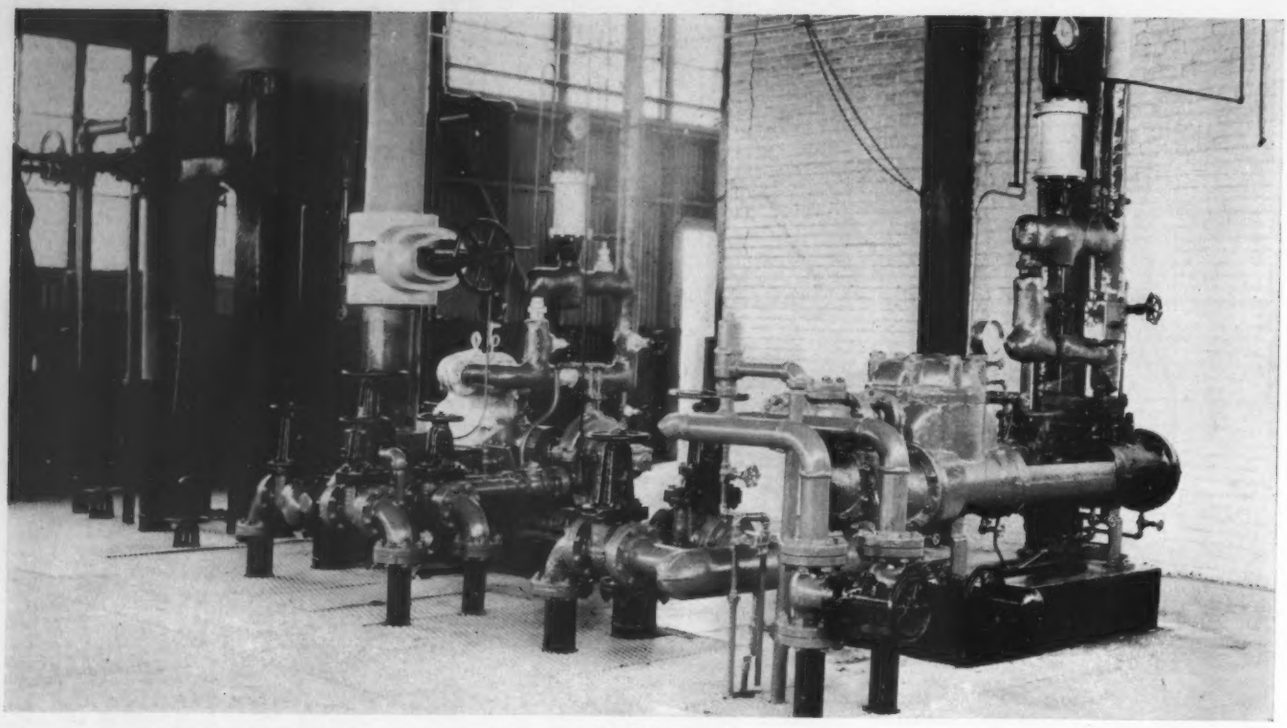
In the fuel supply control the regulator is so piped that damper variation will follow action of the fuel valve.

Synchronized Controls Improve Boiler Operation

SYNCHRONIZING the controls in the boiler room of Union Oil Company's Bell gasoline plant at Santa Fe Springs, California, was accomplished through an arrangement of valves, piping and linkage, so that the draft through each boiler is automatically adjusted to the quantity of steam generated and the amount of fuel consumed. These boilers have multiple service—to generate steam for the gasoline plant; furnish power for drilling wells, and oil treating plants and clean-out operations in the field.

Steam consumption, therefore, is variable ranging from the normal volume required for operation of the gasoline plant to full capacity when the producing department demands large quantities. When the boilers were installed, conventional valve setting was provided for fuel control so that the steam pressure in the header could regulate the quantity of fuel necessary for operation. Pressure on the boilers was held at 190 pounds, gauge, and the fuel was reduced from about 40 pounds, gauge on the upstream side of the regulator, to 1.3 inches mercury pressure, shown by an indicating U gauge on the down-stream side between the fuel pressure-reducing valve and the burners in the combustion chambers.

Before the present equipment was installed, the dampers in the stacks were controlled manually,



Pump capacity is maintained by having the water level regulation synchronized with the fuel valve and the damper controllers.

sometimes requiring adjustment several times each hour. Tests of stack gases showed that for a part of the time perfect combustion was being obtained, but at other times either an excess of oxygen was present, or the restricted draft prevented complete burning of the fuel. To correct this condition, each boiler was equipped with an automatic damper controller.

Supersensitive vacuum-control valves had been used on field lines leading to the gasoline plant, and when another system was installed, some of these valves were thrown in the idle material bins. These valves have a removable top section containing the diaphragm case with the stem extended through the top with a packing gland and a weight arm and compensating spring. This top section was unflanged and placed on a blank base, which in turn was mounted on a bracket which was welded to one of the vertical I beams of the boiler setting. It was placed behind the boiler directly beneath the damper case on the breeching, and close enough to the building floor for comfortable adjustment when tests are being made of stack gases. The unit was installed as closely to the brick walls as possible, with the weight adjustment arm parallel to the wall.

The damper in the breeching is balanced so only a slight exertion on the lever moves it either closed or open, and a ¼-inch joint of pipe is connected with clevises to both the damper arm and the weight arm of the sensitive vacuum valve head. Several adjustment holes were drilled in the vacuum valve arm, and a turnbuckle set in the lower end of the connecting rod for additional fine adjustment of the travel of the damper controls. Coarse adjustment of the damper travel is obtained by setting the clevis and pin in either of the several holes for preliminary setting, but finished in setting by working the turnbuckle.

The diaphragm section of the vacuum regulator operates the boiler damper through impulses from the fuel regulator valve.

As the pressure on the fuel between the pressure-reducing valve in the fuel header and the burners varies according to the volume of fuel flowing to the combustion chambers, this variation is employed to operate the vacuum valve head through a connecting pipe fitted to the down-stream fuel supply and the lower side of the diaphragm case of the vacuum valve. As the fuel volume increases, greater pressure is exerted on the fuel, which in turn forces the diaphragm to push the spring loaded stem upward, which in turn lowers the outer end of the adjusting arm. This movement transmitted to the damper opens it the amount predetermined by the setting of the connecting linkage. For the opposed adjustment, when the steam in the boilers is at peak pressure, and the load light, the pressure on the down stream side of the fuel system drops accordingly. The spring-loaded stem of the vacuum valve head pressed downward which in turn closes the dampers to compensate for reduced fuel consumption.

Frequent tests of stack gases were made after the controls were installed so that micrometric adjustments might be made over the entire travel range of the dampers and controllers. After these were made, the operation of the assembly became fully automatic and requires no further adjustment, except as pins become worn, which would tend to throw the adjustment out.

Plant Layout Fitted to Climatic Condidions

CLIMATIC conditions in the Permian Basin of West Texas were given consideration in the design of the natural gasoline plant of Cabot Carbon Company in the Estes pool, Ward County. Summer temperatures prevail from mid June to the middle of September, and maximum temperature is frequently higher than 110° F. Records of one day in June of 1939 showed a variation of 77° F. to 112° F. on the dry bulb. Dry atmosphere plus a constant wind resulted in pan temperatures in the main commodity-cooling tower of 82° F.

Direction of prevailing winds from the southwest resulted in placing the engine and compressor building on the east side of the site. Power ends of the engines are placed toward the east. Both exhaust and intake headers are on the west side of the building. Engine exhausts with individual mufflers for each cylinder run through the roof.

Distillation and absorption units are in the center of the grounds. The main cooling tower is on the north side. Storage tanks are in the northwest corner, far enough from fires to provide maximum safety.

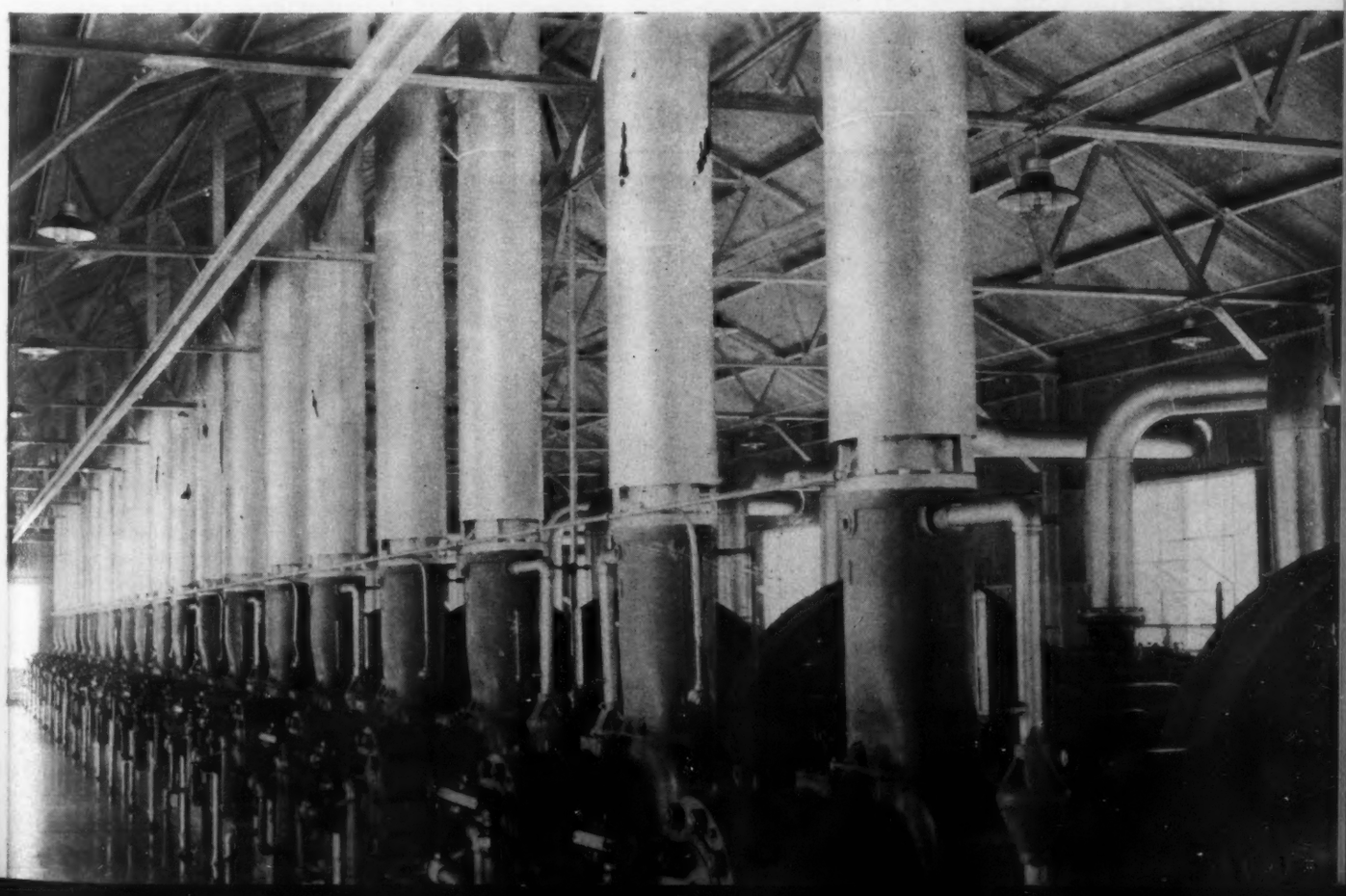
The engine room is equipped with 10 twin, horizontal gas engines with 17-inch by 20-inch power and compressor cylinders which provide 2500 horsepower. Floor space between each end of the engines and the walls of the building is ample for operating the equipment and making repairs.

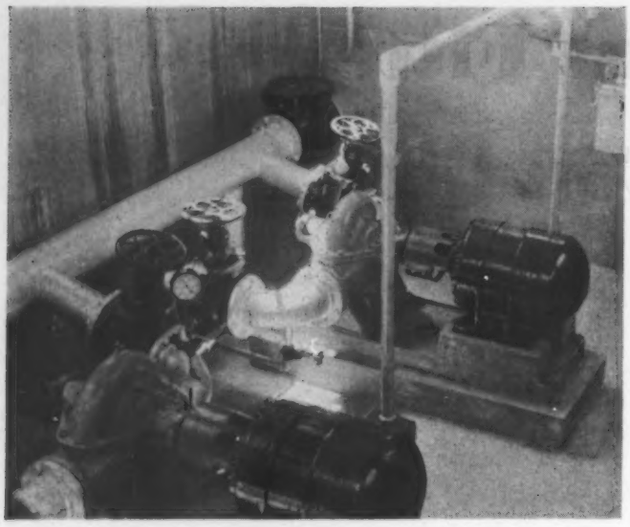
An overhead trolley extends the length of the engine room above the power cylinders so that a mobile chain hoist may be used for removing heads and pistons. One end of the engine room has a parts cabinet and rugged mechanic's bench. The trolley extends over this so that large parts may be transferred to the work bench.

Gate Valves Outside

The compressor intake piping rises from the suction flange on top of the cylinder with welded ells for connections to a common suction pipe extending through the building wall, and thence to the main suction header above the ground level. All gates to control gas from the field and to the absorbers are installed on the headers and individual piping outside

Power end of ten gas engines in Cabot Carbon Company's Estes gasoline plant.





Water Pumps

the engine room, so that if stuffing boxes on gate-valve stems should leak, the inflammable vapors will dissipate to atmosphere.

All gas enters the suction header at from two to three inches Hg vacuum, and as many of the wells are rotated to conform with proration schedules, the volume and the intake seldom varies.

Water Consumption

About 80,000 gallons of water are introduced into the plant cooling system daily during the period from May to October when humidity is lowest, as make-up to compensate for evaporation. Little water is lost through drift, as the cooling tower is designed for high wind velocities. Atmosphere cooling sections are placed in the lower section of the tower, just above the basin pan through which materials in process pass for temperature reduction. The gas from the compressors, at 35 pounds pressure, is cooled to an average of 85° F. before entering the two absorption columns.

Motor-driven centrifugal pumps handle the mineral seal oil at 600 gallons per minute, delivering it to the absorbers at 91° F. when the usual load of 26,000,000 cubic feet of gas is processed. These pumps and explosion-proof motors are on a single concrete base, spaced well apart.

A wide concrete slab is laid around the base of the concrete pump foundation so that tools and parts may be laid upon it without becoming fouled with sand. The cables are in conduit and connected with explosion-proof fixtures to motors and control instruments.

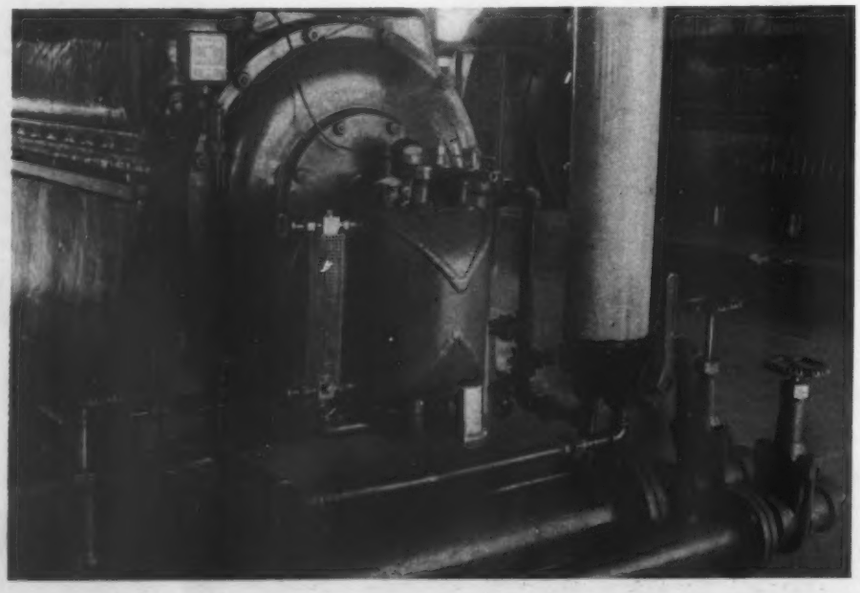
The gas entering the absorbers has a composition as follows:

Fraction	Percent	G. P. M.
Methane	86.39	
Ethane	6.48	
Propane	3.94	
I-Butane	.31	
N-Butane	1.68	.53
I-Pentane	.31	.11
N-Pentane	.34	.12
Texane and Heavier	.55	.24
Total	100.00	1.00

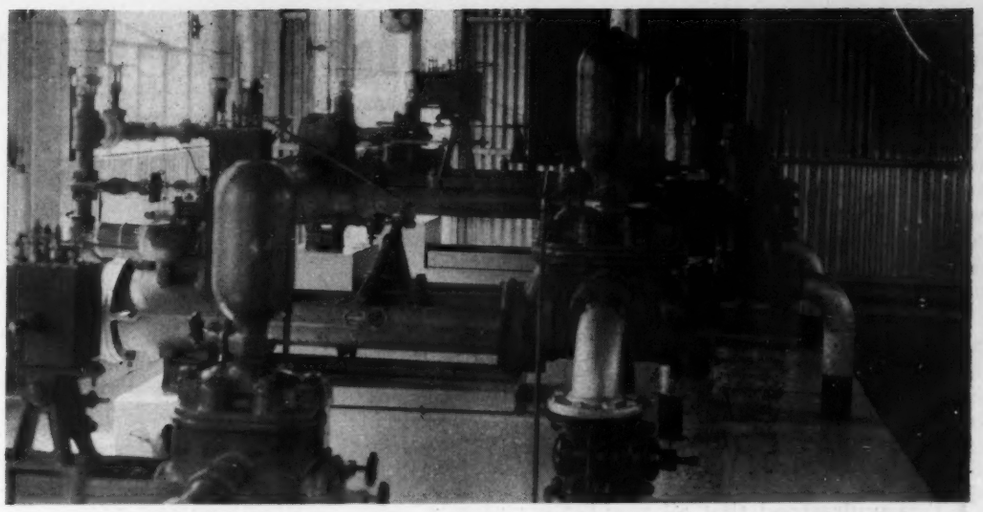
From this gas, the average daily production is 29,000 gallons of 26/70 natural, but the analysis indicates that almost double that gallonage could be obtained, if all the propane was extracted.

Oil from the absorbers (temperature 91° F.) is pumped from a surge tank through the distillation apparatus, leaving the exchangers and preheaters at 325° F. The still is operated at 50 pounds, gauge, pressure and at a temperature of 377° F. Vapors are condensed and liquified to 88° F., and pumped from the make tank to the stabilizer. At a rate of approximately 1200 gallons per hour, the raw production is fractionated at 250 pounds, with the reboiler temperature of 292° F., maintained partly by exchange of heat and partly by superheated steam.

Overhead temperatures are provided by pumping condensate from the stabilizer overhead vapor condenser, and held at a normal rate of 130° F. The



Oil pot used by Cabot Carbon Company, in its Estes, Ward County, Texas, gasoline plant to force a flood of lubricating oil to engine bearings before starting.



Pumps in gasoline control room of Estes plant.

vapors are vented from the accumulator drum at the stabilizer and introduced into the residue pipe line leading to the carbon black plant. Operation of the stabilizer varies from season to season. During summer the reflux required for efficient fractionation has a ratio of 1:1, reflux to waste, and during winter, the ratio is maintained at 3:1.

Electric power requirements of the gasoline plant and the carbon black plant are provided by three 360-horsepower vertical gas engines, each connected to a 250-kilowatt generator. Distribution of energy is, 125,400 K.W.H. to the carbon black plant, and 157,400 K.W.H. to the gasoline plant. One unit serves as standby.

To insure proper lubrication of connecting-rod and main-journal bearings in these engines, an auxiliary lubricator forces a flood of oil through the force-feed pipes and to the bearings just before applying the starting air. The auxiliary oiling apparatus consists of a drum, made of line pipe, having a capacity of about 2½ gallons. It is installed in the force-feed lubricating system, between the circulating pump, oil filters and the distribution piping of the engines. With a system of by-passes, gates and piping, the lubricator drum may be recharged after the engine is started by opening a filler gate and allowing oil to flow from the filters into the unit. A connection between the lubricator drum and the starting-air system, and when the engine is spotted and just prior to admitting the air, pressure is applied to the drum and oil forced through the lines to the bearings and crank shaft journals. This method insures a plentiful supply of oil without waiting for the regular oil system to operate.

Water Loss Low

Steam is provided by four oil-field-type boilers. The pressure maintained on the boilers is 200 pounds, gauge, and the boiler-feed water is heated to 192° F. before it enters the shells through the water controllers. Plunger pumps are employed as boiler-feed units, outside packed and installed near the boilers with the pumps that handle the makeup water and operate the boiler feed preheaters. The condensate from the process pumps and other units is all returned to the boiler room for makeup, consequently, little raw water is required for the boilers. With close attention given the fittings, gates and packing of pumps the loss of condensed water is held to a minimum.

The engine room is maintained to obtain adequate delivery of gas from the field to the absorbers, and lubrication checked frequently and thoroughly. It is shown by plant records that the consumption of engine lubricants is exceptionally low, indicating that 5500 horsepower hours are obtained for each gallon of oil placed in the engines. This record is obtained in part by prevention of leaks in distribution piping from lubricators to cylinders, maintaining adequate packing and seals on inspection plates, and proper packing on the piston rods.

Electric motors and oil circulating pumps, Cabot Carbon Company's Estes gasoline plant.

Caustic Embrittlement of Steam Boilers

By W. S. CAZORT, JR.
Chief Chemist, Terminal Refining Corporation

IT is understood that all raw waters require some chemical conditioning before becoming suitable boiler feed. One type of water which has heretofore escaped being classified in the category of unsuitable for boilers is very soft water containing a relatively high concentration of sodium carbonate.

Feedwaters of this type arise from two sources; the first being alkaline water containing sodium carbonate and sodium bicarbonate naturally; the second being water which has undergone softening treatment either from maintaining an excessive concentration of sodium ash or from processing extremely hard water with a zeolite or similar type softener.

Zeolite-type water softeners simply convert incrustants, or scale-forming ingredients, (viz. carbonates, bicarbonates, and sulphates of calcium and magnesium) into the corresponding salts of sodium. Zeolite softeners do not reduce the total content of dissolved solids; whereas, lime and soda treatment precipitates out practically all incrustants, leaving only sodium sulphate and sodium chloride which are practically harmless in low concentrations. However, in order to get a soft water using soda ash treatment, it usually follows that an excess of soda ash is used unless chemically analytical control is exercised carefully. Methods for the routine control of waters of this type will be given later.

No treatment should be applied to a water until a representative sample has undergone complete chemical analysis. Every boiler feedwater should be analyzed because of the dangers incurred through the use of a bad raw water, and practically all raw waters are bad. The danger which we are dealing with in this paper is, specifically, *caustic embrittlement*, or *hydrogen ion embrittlement*.

Plus Heat

Caustic embrittlement is merely a series of intercrystalline breaks in seams and joints of boiler plates and particularly between rivet holes. This condition results from the conversion of soda ash or sodium carbonate to sodium hydroxide by boiler heat.

$$2\ NaHCO_3 + heat = Na_2CO_3 + 2\ H_2CO_3$$
$$H_2CO_3 = CO_2 + H_2O$$
$$H_2O + Na_2CO_3 + heat = 2\ NaOH + CO_2$$

As can be seen from the above reactions, sodium bicarbonate is converted to sodium carbonate which is converted to caustic soda by boiler heat. Caustic soda in concentrations much higher than two grams per liter under pressure and at a high temperature causes this cracking between rivets and in seams with disastrous results. It must be borne in mind that no steel suitable for boiler plate has been discovered which will in itself resist the embrittling effect of caustic soda. It would be difficult to estimate the damage which has resulted from this condition. Many lives are lost, and much equipment is destroyed unnecessarily, because this condition can be prevented.

A boiler, operating under normal pressure with a normal load, blows up. The cause is usually attributed to a dry boiler into which cold water has been pumped. Usually, this theory is correct, but too often the cause is embrittlement in riveted joints.

There are at least two well known agencies for the prevention of caustic embrittlement; they are soluble sulphate salts and soluble phosphates. It has been found experimentally that a ratio between soluble sulphates present and the alkalinity of the water will insure complete protection from this danger. This ratio is called *sulphate to carbonate ratio* and rises in direct proportion to the boiler pressure or water tem-

Usually, when a boiler operating at normal pressure blows up, the cause is attributed to a dry boiler into which cold water has been pumped. But cold water did not cause destruction of the boiler, remains and not destruction shown above.

perature inside the boiler. The following table will apply:

Boiler Pressure	Sulphate-Carbonate Ratio
50—150	1 to 1
150—250	2 to 1
250 and above	3 to 1

Therefore, if a boiler is operating under 175 pounds and there is twice the amount of soluble sulphate in the blow down that there is alkalinity, one may have complete assurance of protection against this danger. Most alkaline waters contain quantities of sodium sulphate; so it becomes necessary to make up only the deficiency determined by analysis and thereby avoid the expense of maintaining a large excess, although sodium sulphate in itself is perfectly harmless when not excessively concentrated.

Two Ways to Go

There are two ways of introducing soluble sulphates into a boiler. The first and simplest way is merely to add dry sodium sulphate to the feedwater either in the feed lines or in a treating tank. One cannot go wrong on this treatment if he uses plenty of sulphate and makes judicious use of the blow down. The second and most efficient means of introducing sulphates to an alkaline water is the use of a good grade commercial sulphuric acid. This must never be done except under the direct supervision of an analytical chemist who is seasoned in the treatment of water. This method has its distinct advantages in that the acid partially neutralizes the alkalinity thus requiring less sulphates.

$$Na_2CO_3 + H_2SO_4 = Na_2SO_4 + H_2CO_3$$
$$H_2CO_3 = H_2O + CO_2$$

It is seen by the above reaction that much less total dissolved solids remain in the water than in the treatment by addition of sodium sulphate, because carbon dioxide is liberated. The addition of two parts acid to three parts sodium carbonate will reduce the carbonate to one third its original concentration and leave a ratio of sulphate to carbonate of two to one. This treatment must be done in the open where the water can be thoroughly agitated to drive off carbon dioxide and any free sulphur dioxide that might have been in the acid. At no time should sufficient acid be used to neutralize all the alkalinity, for pitting would result.

Although the sulphate treatment has been used for some time and is universally recognized, the phosphate treatment is rapidly gaining in favor. Phosphate has several advantages in that it is easily applied, it is not expensive, and a highly alkaline water may be conditioned without using an excessive amount of chemical. It is difficult to say which of the treatments is the more expensive because of the wide range of prices of the chemicals themselves and also difference in freight costs for various localities. Generally speaking, phosphate is cheaper; because soluble phosphate is many times more effective than sulphate and consequently much less chemical is used. As in the case of sulphate treatment, soluble phosphates are commonly introduced in either of two compounds. Di-sodium phosphate is a neutral compound which has no effect on water PH value.

Phosphate Use

In the proportion of one gram per liter, phosphate will guard against any concentration of caustic soda commonly found in a boiler. This means that a sample of blow-down water should show this concentration at all times, or assuming the concentration ratio to be 15 to 1, it means that 0.82 pounds of di-sodium phosphate per thousand gallons of raw water must be added. The other phosphate salt commonly used as an embrittlement inhibitor is mono-sodium phosphate or sodium acid phosphate. This compound has an acid reaction; it also contains more phosphate pound for pound than di-sodium phosphate. As in the case of sulphuric acid, this compound enters into combination with either sodium carbonate or caustic soda. Unlike sulphuric acid, it can be handled safely, does not require quite the supervision, and may be introduced directly into the feed lines. In spite of the fact that the right concentration of inhibitor will insure against embrittled plates, it is wise not to allow the caustic concentration to become too great. It is, therefore, wise to use an inhibitor which will lower the caustic concentration, lower the total dissolved solids, and at the same time give protection against caustic. The reaction between sodium acid phosphate and sodium carbonate is analogous to that between the salt and sulphuric acid.

$$2\ NaH_2PO_4 + Na_2CO_3 = 2\ Na_2HPo_4 + H_2CO_3$$
$$H_2CO_3 \text{ decomposes to } CO_2 + H_2O$$

Thus it is seen that alkalinity is decreased, the concentration of total solids is less than in the case of addition of di-sodium phosphate.

Determination of Alkalinity

Once the problem is understood, the technique of guarding against embrittlement is quite simple.

For plants which do not require the regular employment of an analytical chemist, we offer the following detailed methods:

Materials:

1 100 cc. Burette
1 10 cc. Pipette
1 Ring Stand and Clamp for Burette
1 Liter Tenth Normal Hydrochloric Acid
100 cc. Neutral Methyl Orange Solution
2 1000 cc. Beakers
1 1000 cc. Volumetric Flask
1 100 cc. Volumetric Flask
5 gallons distilled water

To determine the alkalinity of a sample of raw water, measure exactly 1000 cc. of the sample in a volumetric flask, transfer this water to a 1000 cc. beaker and evaporate nearly to dryness, being careful that none boils over or splashes out. When the sample is reduced to approximately 20 cc., allow it to cool and transfer it to a 100 cc. volumetric flask. Rinse the beaker thoroughly several times with 10 cc. portions of distilled water, and pour rinsings into the 100 cc. flask with the residue of the sample. Add enough distilled water to bring the level of the liquid to the 100 cc. mark. The original sample is now concentrated exactly ten times. With the 10 cc. pipette, withdraw exactly 10 cc. of this concentrated sample and pour it into a beaker; add two or three drops of methyl orange solution. Fill the burette with the standard hydrochloric acid, and note the reading. From the burette, drop hydrochloric acid into the 10 cc. portion of the concentrated sample until the color of the solution changes from yellow to salmon—not red. This is the methyl orange end point. Care must be exercised to keep the sample agitated while this titration is in progress, or at the end point will not be distinct. Two successive titrations of 10 cc. portions of the concentrated sample should not differ one from another by more than 0.025 cc. The number of cubic

centimeters of acid used for a 10 cc. portion of the concentrated sample multiplied by 0.053 gives the total alkalinity calculated as sodium carbonate in grams per liter. Grams per liter multiplied by 8.354 gives alkalinity as sodium carbonate in terms of pounds per thousand gallons.

To determine the alkalinity of boiler blow-down water, measure 10 cc. blow-down water with a pipette into a beaker. Titrate with tenth normal hydrochloric acid as in the case of the raw feedwater. Multiply the number of cubic centimeters of hydrochloric acid used by .53, and the result is grams per liter of total alkalinity calculated as sodium carbonate. This concentration should be maintained at as near to two grams per liter as possible. This is done by the conscientious use of the blow-down as well as through chemical conditioning.

Sample Calculation

Let us take a hypothetical case. A raw feedwater is concentrated 10 times, and 10 cubic centimeters are titrated against tenth normal hydrochloric acid. 7.25 cc. of hydrochloric acid are required to neutralize the sample.

$7.25 \times .053$—0.3842 g/l Na_2CO_3 in raw water.

0.3842 g/l—3.2096 lbs. Na_2CO_3 per 1,000 gal. raw water.

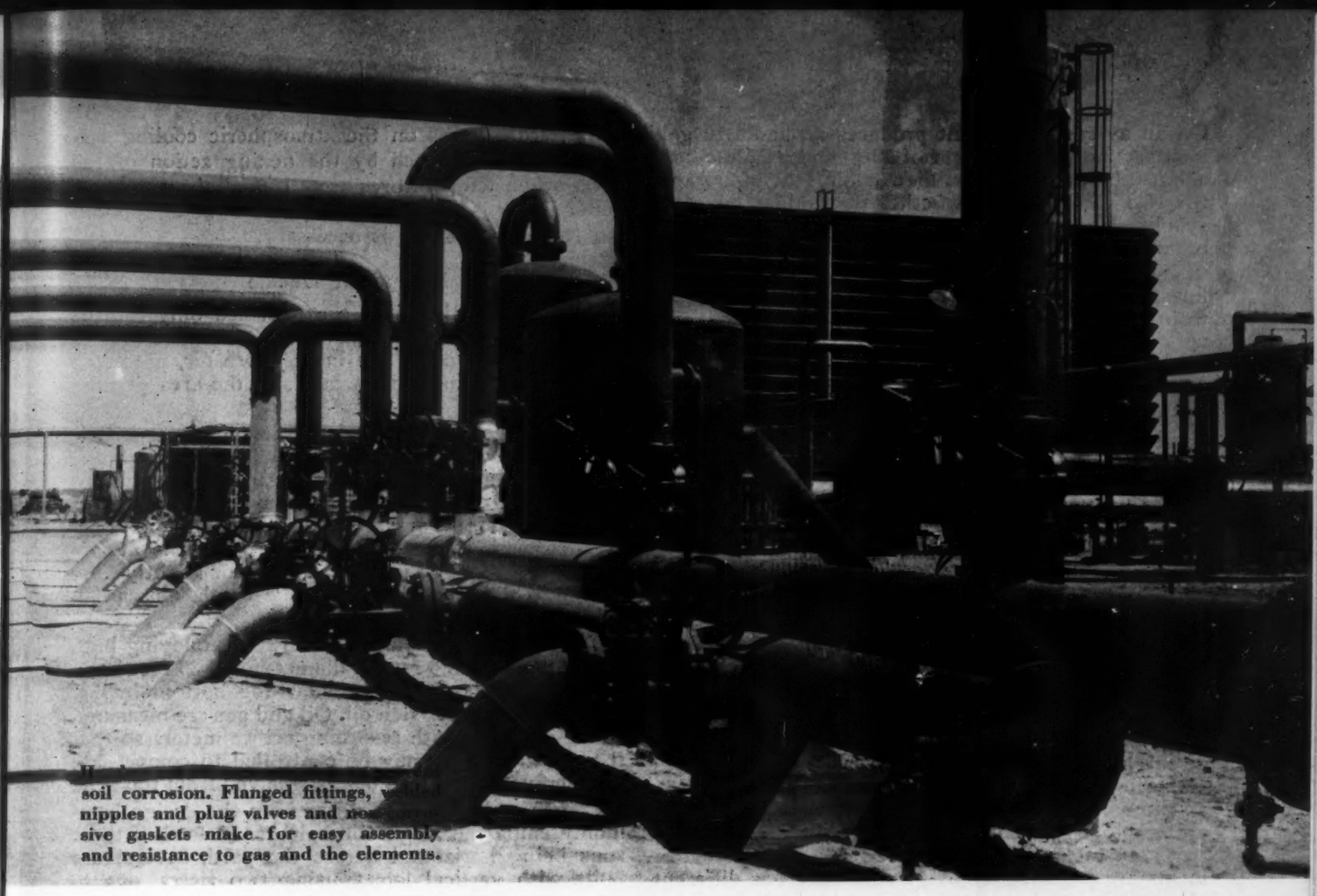
500-boiler horsepower require 48,960 gallons of water evaporated per day. Assuming 40 percent return, we evaporate 29,376 gallons of raw water daily. 29,376 gallons of this water contain 94.28 pounds Na_2CO_3. Assuming the boiler pressure to be maintained at 200 pounds, it is necessary to maintain a sulphate-carbonate ratio of 2 to 1. In order to have complete protection from caustic embrittlement, it is necessary that 188 pounds sodium sulphate enter the boiler per day. The raw water contains naturally 0.173 g/l of sodium sulphate which equals 42.58 pounds per 29,376 gallons. This means that 145 pounds dry sodium sulphate must be added to the feedwater per day.

When sulphuric acid is used, much less chemical treatment is necessary; but much closer control must be exercised, and the treatment must be made in an open tank. The addition of 49 pounds per day of sulphuric acid will reduce the concentration of sodium carbonate to 41.28 pounds per day while, at the same time, the concentration of sodium Sulphate is increased to 71.03 pounds per day plus the 42.58 pounds in the original water, or a total of 113.61 pounds per day of sodium sulphate which is a ratio of more than 2 to 1 and which gives us an ideal water with much less total solids than in the above case. After treatment, the sulphate in the water can be approximated by the reduction of alkalinity or the total sulphate can be determined directly by any one of several standard methods.

One gram per liter of soluble phosphates in the boiler will guard against any reasonable concentration of caustic soda; so, as was stated before, 0.82 pounds of di-sodium phosphate per thousand gallons of raw feedwater will be sufficient when the blow-down shedule is such that the concentration ratio is about 15 to 1. Due to the fact that the inhibitive effect of soluble phosphates is many times greater than that of sulphates, most authorities recommend even a much lower concentration than this. Experiments have proved that a small fraction of this amount will effectively render boiler plate safe from embrittlement. The most common recommendation is ¼ pound per thousand gallons of raw water. However, in order to be absolutely safe, it is wise to adhere to the practice of maintaining a concentration of 1 gram per liter where alkalinity is high.

Sodium acid phosphate is probably the ideal chemical to use for the condition under discussion. This compound will neutralize alkalinity but does not form free acid and can be injected directly into the boiler. The only danger to guard against in its use is that of reducing the carbonate concentration to zero which might lead to scale formation or pitting. When used in the proportion of ½ pound per 1000 gallons, this compound is safe and effective. In some cases, even less than this may be sufficient as would be seen in the titrations of the blow-down water. If the blow-down water shows less than 2 grams per liter, less than ½ pound per 1000 gallons would be necessary. Concentrations greater than 10 grams per liter show need of longer and more frequent blow-downs.

Bad feed water which resulted in embrittlement of the boiler plate is given as the cause of explosion of this boiler



soil corrosion. Flanged fittings, w
nipples and plug valves and no
sive gaskets make for easy assembly
and resistance to gas and the elements.

Gas Lift Combined With Gasoline Manufacture

PROVISION for gas-lift production near Odessa, Ector County, Texas, was included in the design of the natural gasoline plant of Barnsdall Oil Company, which was put in operation in 1938. The plant is also designed for a varying gas load, whose peak is 12,000,000 cubic feet daily.

Although the gas is not as rich in hydrogen sulfide as some areas of the Permian Basin, the amount is sufficient that equipment, other than engines and boilers, is in the open to prevent any poison-laden atmosphere collecting and becoming a hazard.

All gas produced is under low pressure, and to handle the volume expected during peak producing periods, six 165-horsepower, twin, horizontal gas engines were installed. Together with these six machines, two 230-horsepower twin, horizontal engines were set to compress the residue gas for use in gas lifting oil from wells.

Capacity of the plant is such that a peak load of 12,000,000 cubic feet of gas can be processed in 24 hours. Design of the distillation and stabilizing apparatus is such that a greater volume may be handled with the additions to the compressor facilities and to the absorber capacity. Gas in the Foster pool, however, contains only 2900 grains of hydrogen sulfide, but this percentage is great enough to create processing difficulties and contribute hazards of operation and increase difficulties in treating. Therefore, a number of applications were installed when this plant was built to cope with the sourness of the gas and to reduce the raw product to a sweet and noncorrosive natural gasoline.

Gasoline Content Varies

The quality of this gas, in so far as gasoline content is concerned, varies by the method of producing the oil. Field tests indicate that the content ranges from 1 to 4 gallons per million cubic feet. but the average is around 1.20 gallons. Content of the gas may range from 1 gallon up to 4 gallons, depending upon the class of wells from which gas is being taken, and also on the manner in which the wells are produced, whether they are opened wide for the daily allowable, or produced in a more orderly manner.

On an average, the plant produces around 1.10 gallons per million cubic feet of 18-pound gasoline, and about 1.00 gallon per million cubic feet of butane, the two varying upon whether the main product of gasoline requires a larger or smaller quantity of butanes for vapor-pressure control.

The gas is received through three trunk vacuum lines. The vacuum is held down as low as possible to bring in the gas without excessive back pressure upon the field equipment, and so that a minimum amount of air will be drawn into the gathering system. A high vacuum is most detrimental in a field of this nature where quantities of H_2S are contained in the gas, due to the higher rates of corrosion of equipment when this sulphur compound is acted upon by oxygen and passed through iron or steel pipes and vessels.

Special Fittings

To lower the percentage of leaks in a complex gathering system, where air will be infiltered with the gas, and to prevent escape of gas within the plant area, lubricated plug valves are used extensively on piping where positive control of flow is required. Special welding fittings are used to promote smooth flow of gas and commodities in the plant, particularly on vacuum cylinder intake and discharge lines and headers. Flanged fittings with corrosion-proof gaskets are used at other points, and in some classes of connections, screwed fittings are employed.

Water, too, is a problem in the area. Plant requirements are provided by two wells. Each has different characteristics, but the hardness of both is great. The scale forming minerals range from 40 to 80 grains. The well producing the lowest mineral content water is used for steam. Naturally, with 80 grain water, scale forms on the atmospheric cooling sections, but is removed by the flexing action of the tubes when temperatures are changed abruptly. The boiler water is treated to lower the mineral content, but frequent cleaning is necessary.

Equipment Ouside

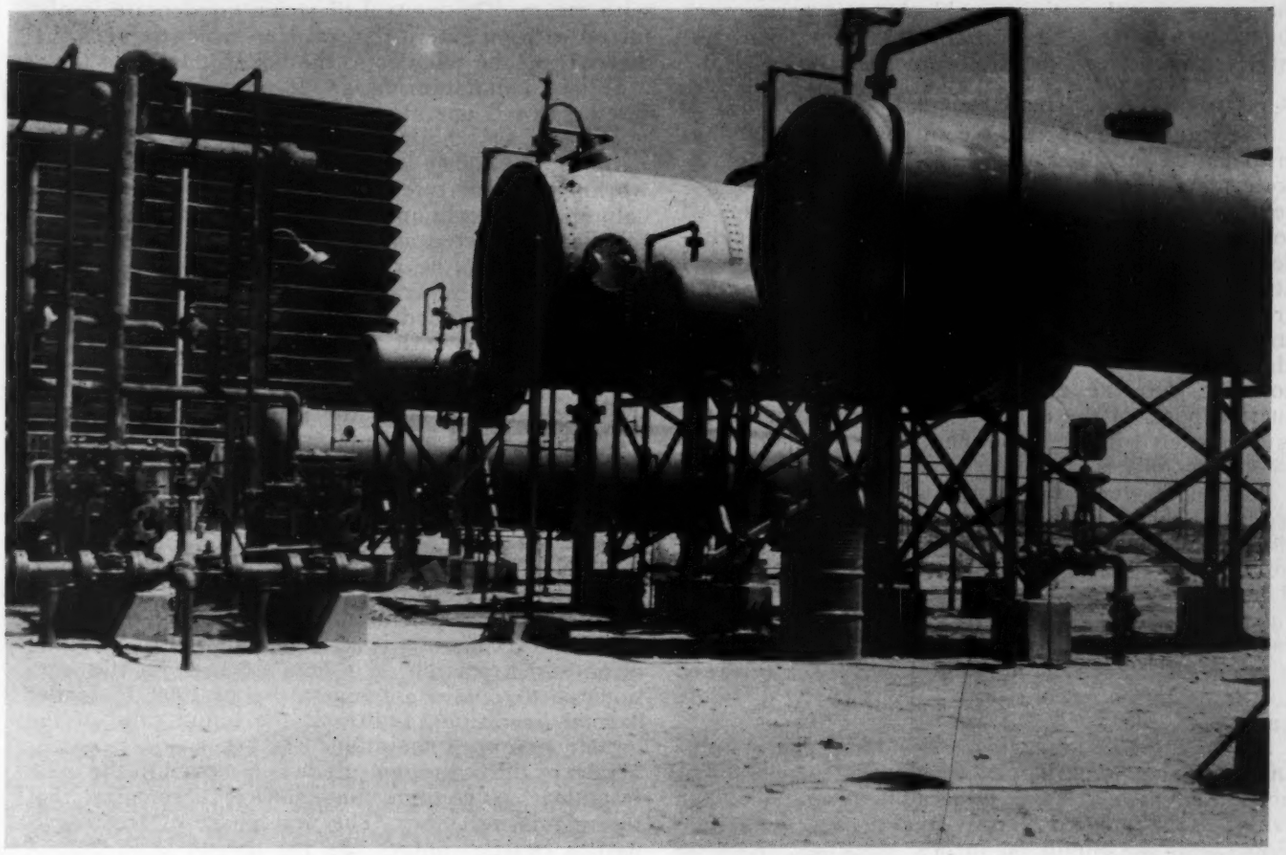
Buildings in the plant are provided only for the engines and the boilers. Pumps, as accumulator tanks and other equipment, are in the open air, protected by a coat of paint. Mild winters in the area permits such practice.

An average of 2 inches Hg. vacuum is carried on the engine compressor headers, which, through the large trunk lines provides a pressure approximating atmospheric to be maintained on the laterals connected to the traps and separators. Through one stage of compression, the gas is delivered to the atmospheric coolers at 40 pounds. At this, or slightly lowered pressure, the gas enters the single absorption column.

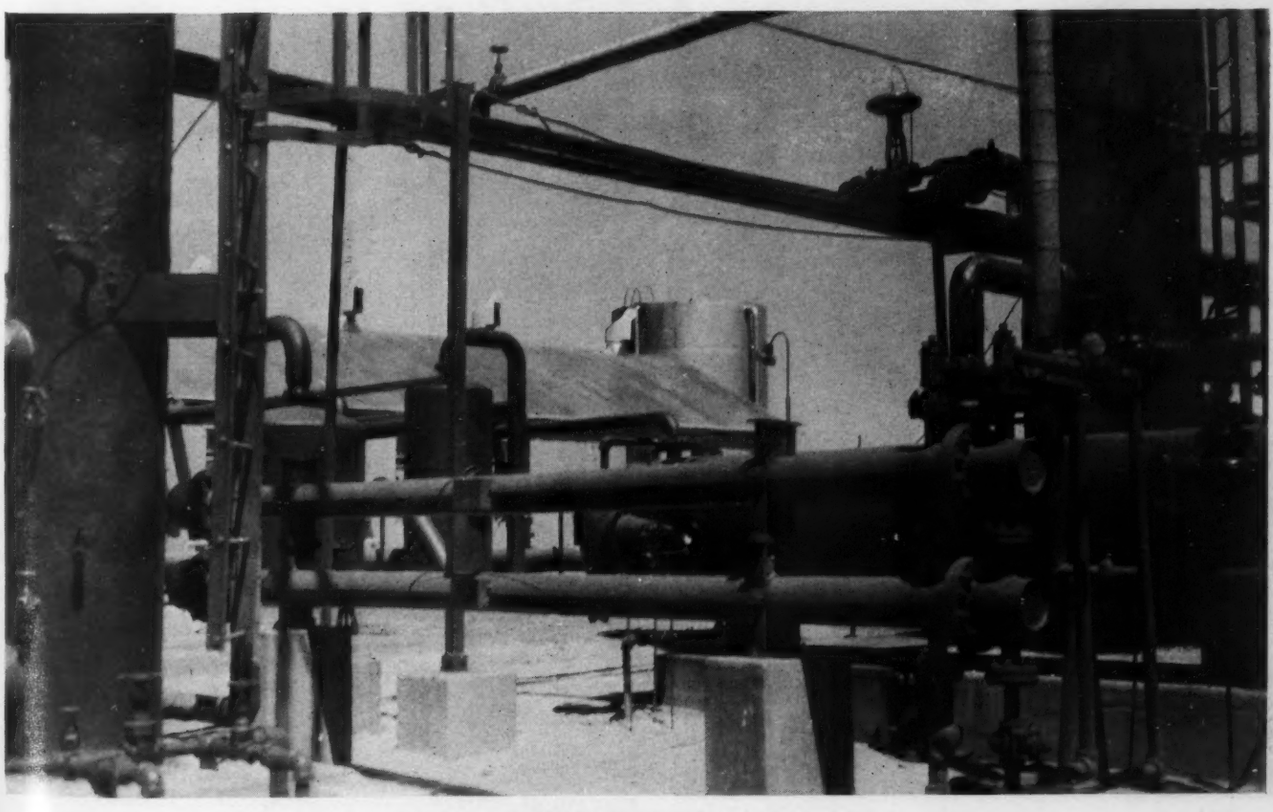
The absorption column is a tower employing bubble plates, and is 6 feet in diameter and 33 feet high, built with a large space below the bottom bubble plate to contain the rich oil. Oil and gas are measured at the absorber with recording orifice meters so that the amount of oil may be controlled to compensate for the fluctuating load of gas received from the field.

Orifice meter settings differ from the design commonly employed in gasoline plants. Instead of these runs being horizontal across the yard, several are built with vertical loops, using two risers, one to carry the product upwards, and the other forming the meter run using the conventional amount of free pipe both up and down stream from the orifice flange. This method of building loops is followed only where

Main accumulator and reflux drum



Caustic wash drums, which remove most of the hydrogen sulfide. Any remaining sulfur compounds are treated out by a solid copper method.



Gasoline exchangers and control equipment

the conventional setting would obstruct passage, as the conventional type is used where they will not interfere with freedom of movement.

Gas Headers

The intake header at the compressors is 20 inches in diameter, installed outside the building upon concrete piers to raise it well above the ground to prevent soil corrosion. It is built in flanged sections. All connections from the headers to the individual cylinder piping are made with welded nipples, and flanged fittings for lubricated plug installation. Blind flanges are bolted to the outer ends of the headers to permit enlargement of plant capacity. The intake piping rises above the header and with welded ells, run horizontally into the engine room to connect to the suction ports of the cylinders. The discharge header is constructed in the same manner as the intake, but is only 12 inches in diameter.

Turbine-driven centrifugal pumps handle oil to and from the absorber, still and vent tanks. The oil from the absorber is pumped through exchangers and preheaters to the still to obtain working temperatures. The still preheated is 19 inches x 20 feet, shell and tube, and is insulated. The still, 68 inches x 29½ feet, is of the liquid reflux dephlegmator types, requiring a certain volume of gasoline to be returned to the top plate to control end point of the distillate vapors.

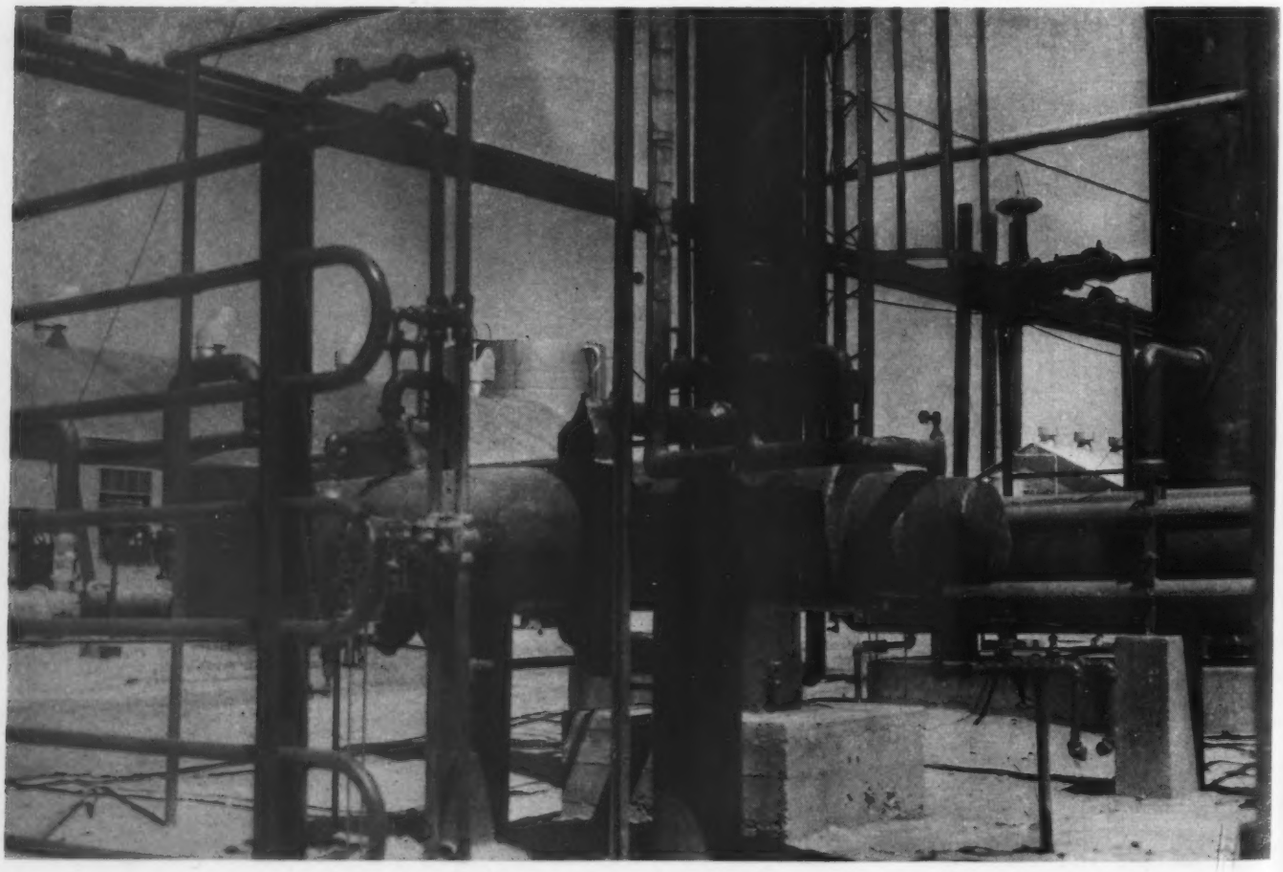
The raw product is condensed in atmospheric units, installed above the pan of the louvre tower, and is accumulated in a large, horizontal make tank from which it is pumped to the fractionator. The fractionator is a column 36 inches x 54 feet, with an external reboiler, 36 x 14 inches, which is operated with steam. The control of steam condensate is obtained with an exterior steam trap which returns the water from the reboiler to the boilerhouse feed tank.

When manufacturing an 18-pound product, this fractionator is operated at a pressure of 180 pounds, with the raw charge entering the tower through bottoms to charge exchangers to obtain adequate working temperatures on the material entering the column. The column is held at 280° F. with the reboiler considered as the column base temperature, and the top of the column is operated at 140° F. The overhead temperature is controlled to the degree desired with liquified overhead vapors, pumped back to the top plate with a ratio of 1:1.

Butane Recovery

The condensate from the fractionator overhead is withdrawn from the reflux accumulator by pumping, and is processed to recover the required butane fractions. This is accomplished in a smaller diameter column, equipped with a small outside reboiler. The butane fractionator is near the remainder of the stabilizing equipment, and is operated at 200 pounds. The reboiler temperature is controlled between 160 and 180° F. to produce commercial liquid butane. Overhead condensate is accumulated in a small reflux drum and a portion of it pumped back to the fractionator to obtain a temperature of 100° F. Under normal operating conditions, the reflux ratio of the butane column is maintained at 1:1.

Part of the hydrogen sulfide is removed in the main fractionating column, but sufficient remains that treating is necessary. The first phase of treating is with a caustic contact and the second is in contact with a solid type of copper treater.



Reboiler and base of butane column

For Cleaning Off-Color Gasoline

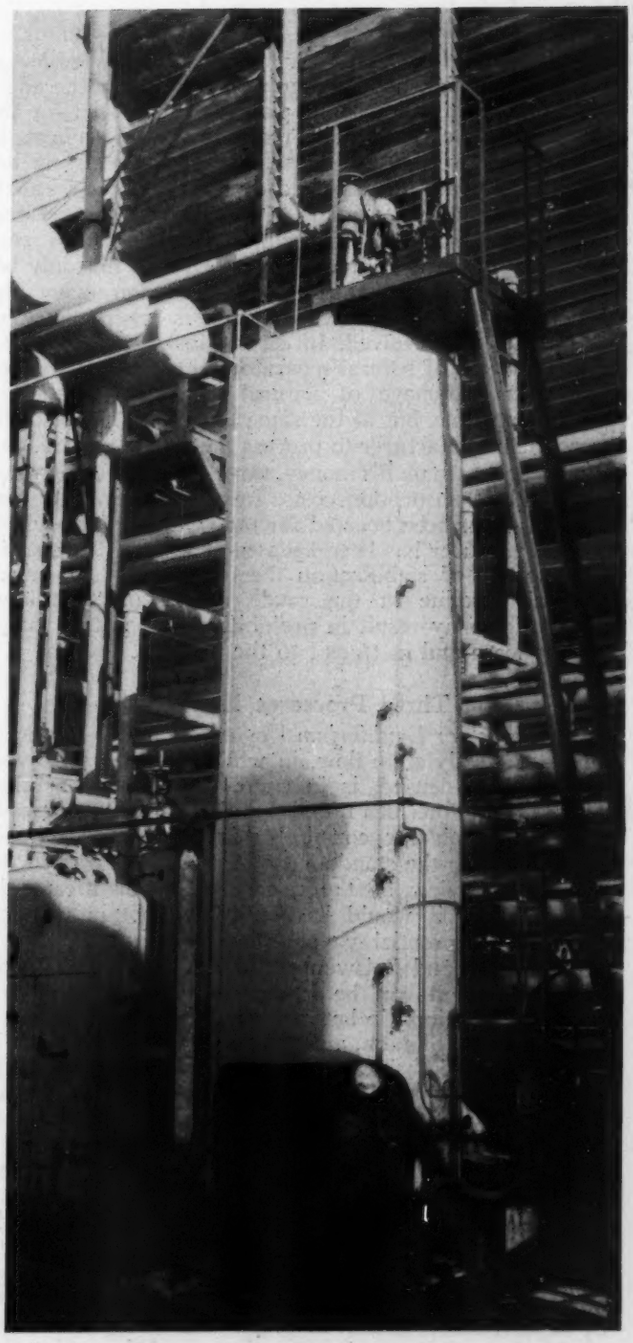
As in other old oil fields, Signal Hill wells produce casinghead and separator gas having a comparatively high gallonage carrying a percentage of high-boiling fractions which condense readily in gathering lines to form pipe line drips. These drips are collected and brought into the plant for processing, and, as they are invariably dark in color, they require distilling to produce a 30 color product for blending with the regular plant production. Gilmore-Dabney, Inc., controls the various characteristics of its finished product which prevent inclusion of "slugs" of drips in the processing system at any time.

To prevent the fluctuation of end point, recovery and vapor pressure of marketable natural, this company processes its drips in proportion to the volume handled, and adjusts the process of clearing up the color and end point to prevent the final stabilizer from requiring adjustment in pressure, temperature and rate of feed. A special drip still was installed in the plant, separate from the plant distillation apparatus, with its feed pump and heating coils controlled as a separate plant.

Adequate storage was provided to accumulate drips as they are delivered from the field, from which a 2 x 4 x 2-inch duplex steam pump takes suction and pumps the material through adequate exchangers to a vertical vessel equipped as a still. The quantity of drips in the storage tanks and those expected from the field is always pretty definitely known, and the small pump is regulated so a volume equal to the receipts is pumped to the still over the full 24-hour day.

No reflux is required as the factions recovered from the drips include all of the hydrocarbons except those which off-color the material. The temperature of the coils in the base of the still is controlled, along with the rate of charge, to distill the volume required, and leave only the heavy oil. The unit is controlled by adjusting the speed of the small pump and the amount of steam required for distillation. Vapors from the drip still enter the plant condensing system to blend automatically with the usual daily production, and the whole is stabilized for final distillation and vapor pressure specifications.

Bottoms from the drip still are bled frequently to the plant slop tanks to mix with salvaged oil from any source, such as crude bled from the gathering system, which is periodically delivered through automatic control to the plant disposal system to prevent spilling on the surface of the ground.



Gasoline is brought to specifications in controlled volumes

Elements of Vaporization and Condensation

PART IV
Stage Separation of Mixtures Containing Three or More Hydrocarbons

R. L. HUNTINGTON, University of Oklahoma

WITHIN the past few years a knowledge of stage separation has become as essential for the engineer in the natural gasoline plant as it has been for the oil-producing engineer. This realization has been brought about by reason of the close relationship existing between the plant and the field operators in their efforts to work out recovery plans which may net the greatest returns per dollar of investment to all parties concerned. This cooperation has been evident, not only between these two departments under common ownership, but also among plants and producers where different companies are involved. In certain instances, the effective operation of several separators in series has reduced the gross gallonage of natural gasoline available in the gas streams, but at the same time it has enabled the gasoline manufacturer to process these gas streams with a greater return on his money, through reduced compression and oil absorption costs. In other cases, the gross gallonage has been boosted for the gasoline plant, where the oil producer has been keen enough to realize that in the absence of stabilization the retention of too much natural gasoline in the crude oil or in "distillate" production may result in prohibitive evaporation losses on the lease and in transit to the refinery.

Three Processes Involved

(1) *Flash or Equilibrium Vaporization*—This process involves steady state flow, in which the vapor evolved, or liquid condensed, is in equilibrium with the other phase. The refiner has found that this type of continuous operation is advantageous in the distillation of crude oil, not only from the standpoint of simplifying the process but also in view of the release of vapor greater in amount than it would be possible to obtain through batch or differential vaporization. Through the work of Piromoov and Beiswenger,[6] the "flash" vaporization of a crude oil can be easily calculated through an empirical relationship between the true boiling point, or differential dsitillation, and the flash curve. In Figure 1, a typical set of flash and differential curves is shown. It is easy to see that with the exception of the front end of the curves, the flash curve gives a greater vapor release for any one temperature.

(2) *Batch or Differential Vaporization*—The shell still represents an illustrious type of differential vaporization in which the refiner used to distill his crude oil by the batch process. The ordinary laboratory tests, such as the A.S.T.M., the Hempel, and the true-boiling-point fractional distillations, also involve the same type of vapor release, in that the vapor is removed from the liquid under constantly changing conditions. In the batch operations just mentioned, the pressure is usually held constant, while the temperature is gradually increased; however, in carrying out the true-boiling-point analysis, both the decrease in pressure and the increase in temperature are resorted to as a matter of convenience in removing the overhead stream as vapor. Rayleigh[7] has derived an equation for differential or batch distillation.

(3) *Combination Flash and Differential Vaporization*—This type of operation is found in the stage separation of crude oil-gas mixtures. The refiner usually wants a maximum release of vapor from the crude in distillation practice, whereas the oil producer more often prefers to retain the maximum amount of volatile fractions in the crude oil as it flows from the final separator into storage. For this reason, differential vaporization or condensation is sought by the oil producer. Since differential vaporization or condensation, in the true sense, would involve a batch operation or an infinite number of separations under a continuous steady state process, the most practical alternative has been evolved through the development of stage separation. By means of a steady flow system, in which the pressure is pro-

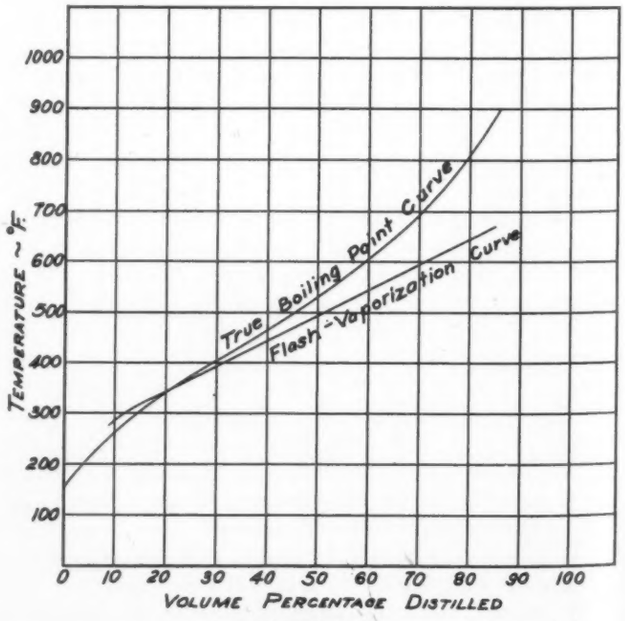


FIGURE 1

Flash and differential vaporization curves from Pennsylvania crude oil. (From Nelson, "Petroleum Refining.")

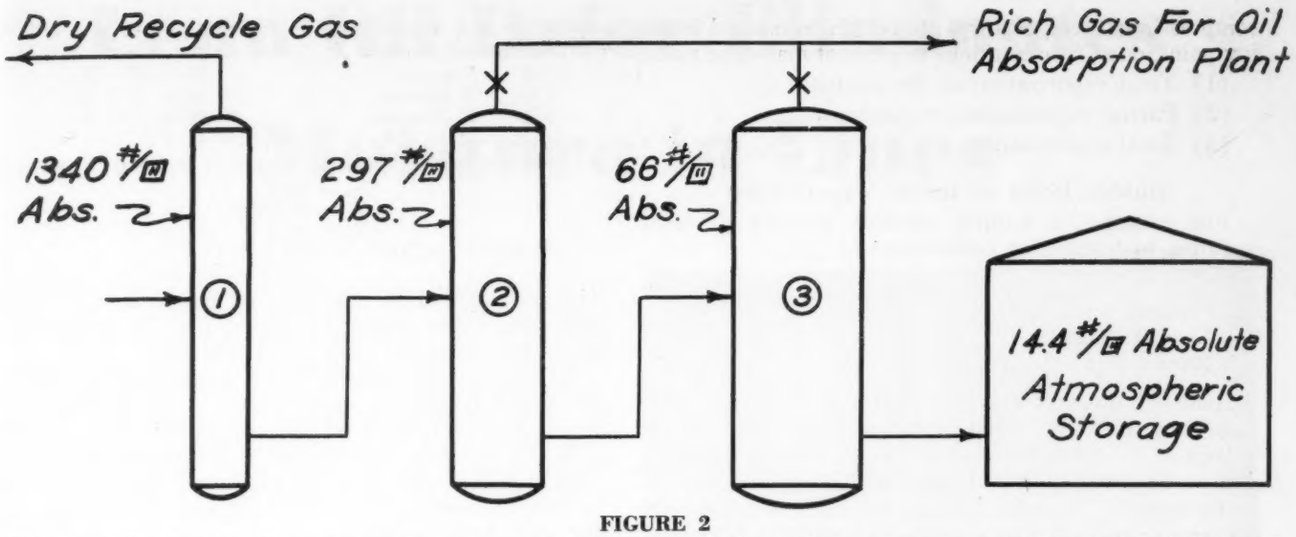


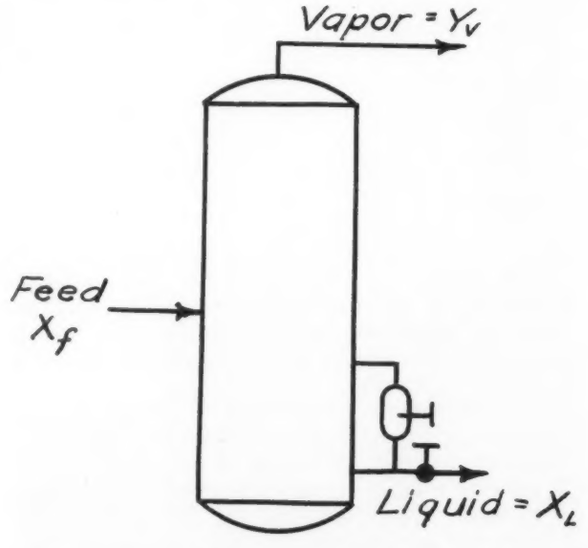
FIGURE 2

Diagrammatic sketch of a three-stage separation installation which involves a pressure reduction ratio of 4½ to 1.

gressively lowered in each separator, a close approach toward true differential vaporization is attained by the use of only three or four separators.[4,5]

Calculation of a "Flash" Vaporization

An empirical relationship, such as the one which has been worked out for the flashing of crude oils,[6] is needed for the simplification of calculations for stage separation, but to date no satisfactory correlation of this nature has been developed. In previous papers of this series,[1,2,3] the method of calculating the separation



of two component mixtures of hydrocarbons has been explained. Although the same principles are involved in the handling of three or more hydrocarbons, the calculation requires far more labor, as the trial and error or successive approximation method is the only feasible attack to make. A straightforward algebraic solution of a three component mixture is possible, but it calls for a far greater mass of calculations than the trial-and-error method.

A material balance can be made around a separator into which a stream is flowing, and from which vapor or gas is being removed overhead, and a liquid stream is flowing from the bottom, as shown in Figure 2.

Since the entering stream is quantitatively equal to the outgoing vapor and liquid streams, the balance for any one component may be expressed mathematically:

	Input	Output: Vapor	Output: Liquid
(1)	$X_f = V\,(Y_v) + (1-V)\,X_L$		
(2)	$X_f = V\left(\frac{P}{\pi} X_L\right) + (1-V)\,X_L$		

Since $\pi\, Y_v = P\, X_L$ (from Raoult's Law)

(3) $$X_f = X_L\left[V\frac{(P)}{(\pi)} + 1 - V\right]$$

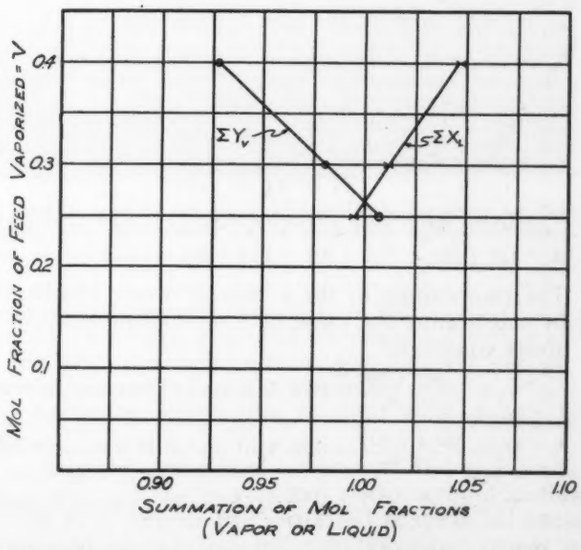
(4) $$X_f = X_L\left[1 + V\left(\frac{P}{\pi} - 1\right)\right]$$

(5) $$X_L = X_f \Big/ \left[1 + V\left(\frac{P}{\pi} - 1\right)\right]$$

If Henry's Law is used, equation (5) can be expressed:

(6) $$X_L = X_f / [1 + V\,(K-1)]$$

Since $Y_v = K\, X_L$



Whenever a mixture of hydrocarbons is subjected to

compression at temperatures above their combined freezing point, one of three things in general may take place.

(1) Total vaporization of the mixture.

(2) Partial vaporization or condensation.

(3) Total condensation.

Bubble Point or Initial Vaporization

For example, a natural gasoline mixture of three paraffin hydrocarbons consisting of:

	Mol %
Propane	30
Normal Butane	30
Normal Pentane	40

is pumped through a coil and into a separator maintained at 100° F. What pressure must exist in the separator to cause the mixture to be entirely liquefied, but at the point of initial vaporization (bubble point)?

By applying Raoult's law, an equilibrium balance can be set up for each hydrocarbon between the liquid and the small bubble of vapor, assuming the amount of vapor formed is insufficient in quantity to cause the liquid to change appreciably in composition.

Partial Pressure in vapor = Partial Pressure in liquid.
Total Pressure × mol frac in vapor = vapor pressure × mol frac in liquid.

(7) Propane $\quad \pi\ Y_3 = 187\ (.30)$

(8) N Butane $\quad \pi\ Y_4 = 52.2\ (.30)$

(9) N Pentane $\quad \pi\ Y_5 = 15.6\ (.40)$

$$Y_3 + Y_4 + Y_5 = 1$$

Adding each side of equations (1), (2) and (3)

$$\pi = 187\ (.30) + 52.2\ (.30) + 15.6\ (.40) = 78.25 \text{ lbs. sq. in. abs.}$$

The composition of the bubble of vapor can be solved by substituting the value of π or total pressure into the above equations.

$$Y_3 = \frac{187\ (.30)}{78.25} = 0.72 \text{ Mol frac of propane in bubble}$$

$$Y_4 = \frac{52.2\ (.30)}{78.25} = 0.20 \text{ Mol frac of N Butane in bubble}$$

$$Y_5 = \frac{15.6\ (.40)}{78.25} = \frac{0.08}{1.00} \text{ Mol frac N Pentane in bubble}$$

In a similar manner, the point at which total vaporization of the liquid occurs is obtained by setting up equilibrium equations.

(10) Propane $\quad \pi\ .30 = 187\ X_3$

(11) N Butane $\quad \pi\ .30 = 52.2\ X_4$

(12) N Pentane $\quad \pi\ .40 = 15.6\ X_5$

$$X_3 + X_4 + X_5 = 1$$

By expressing the liquid fractions in terms of π, such as

$$X_3 = .0016\ \pi$$
$$X_4 = .00575\ \pi$$
$$X_5 = .0256\ \pi$$
$$.0016\ \pi + .00575\pi + .0256\ \pi = 1$$
$$\pi = 30.2 \text{ lbs./sq. in. abs.}$$

The composition of the drop of liquid in equilibrium with the vapor could be determined by substituting back into equations (10), (11) and (12).

As long as the temperature is maintained at 100° F. there will be partial vaporization at all pressures between 30.2 and 78.25 pounds per square inch absolute.

If the mixture is subjected to 60 pounds per square inch at 100° F. the fraction vaporized can be calculated by the trial-and-error method by solving equation (5) for each hydrocarbon:

	Mol Frac	Vapor Pressure at 100° F.	$\frac{P}{\pi}$
Propane	0.3	187.0	3.11
N Butane	0.3	52.2	.87
N Pentane	0.4	15.6	.26

Let V = 0.4 (first trial)

	$\frac{P}{\pi}-1$	$V\left[\frac{P}{\pi}-1\right]$	$1+V\left[\frac{P}{\pi}-1\right]$	X_L	$Y_v = \frac{P}{\pi}(X_L)$
Propane	2.11	.844	1.844	.1625	.5050
N Butane	—0.13	—.052	.948	.3160	.2740
N Pentane	—0.74	—.296	.704	.5680	.1480
				1.0465	.9270

Let V = 0.3 (second trial)

	$V\frac{P}{\pi}-1$	$1+V\left[\frac{P}{\pi}-1\right]$	X_L
Propane	.633	1.633	.1840
N Butane	—.039	.961	.3130
N Pentane	—.222	.778	.5150
			1.0120

Let V = 0.25 (third trial)

	Y_v	$V\left[\frac{P}{\pi}-1\right]$	$1+V\left[\frac{P}{\pi}-1\right]$	X_L	Y_v
Propane	.5740	.5275	1.5275	.197	.613
N Butane	.2720	—.0217	.9783	.307	.267
N Pentane	.1340	—.1850	.8150	.490	.127
	.9800			.994	1.007

Let V = 0.26 (fourth trial)

	$V\left[\frac{P}{\pi}-1\right]$	$1+V\left[\frac{P}{\pi}-1\right]$	X_L	Y_v
Propane	0.5500	1.5500	.1935	.6030
N Butane	—0.0338	0.9662	.3110	.2700
N Pentane	—0.1920	0.8080	.4960	.1290
			1.0005	1.0020

(within the accuracy of the slide rule and other readings).

The number of trials necessary for a solution may be reduced at times by making a graph of three calculations, in which the assumed values of V are plotted against the summation of X_L and Y_v. In Figure 3 such a graph is shown.

Although the trial-and-error method is somewhat laborious, frequent calculations make it possible for an engineer to reduce the required time appreciably. Whenever a large number of components is present in a mixture, approximations can be made by selecting certain key components. In view of the large number of calculations which are being made today on stage separation installations, it is probable that short cuts will be developed which will greatly simplify the work required for obtaining satisfactory solutions.

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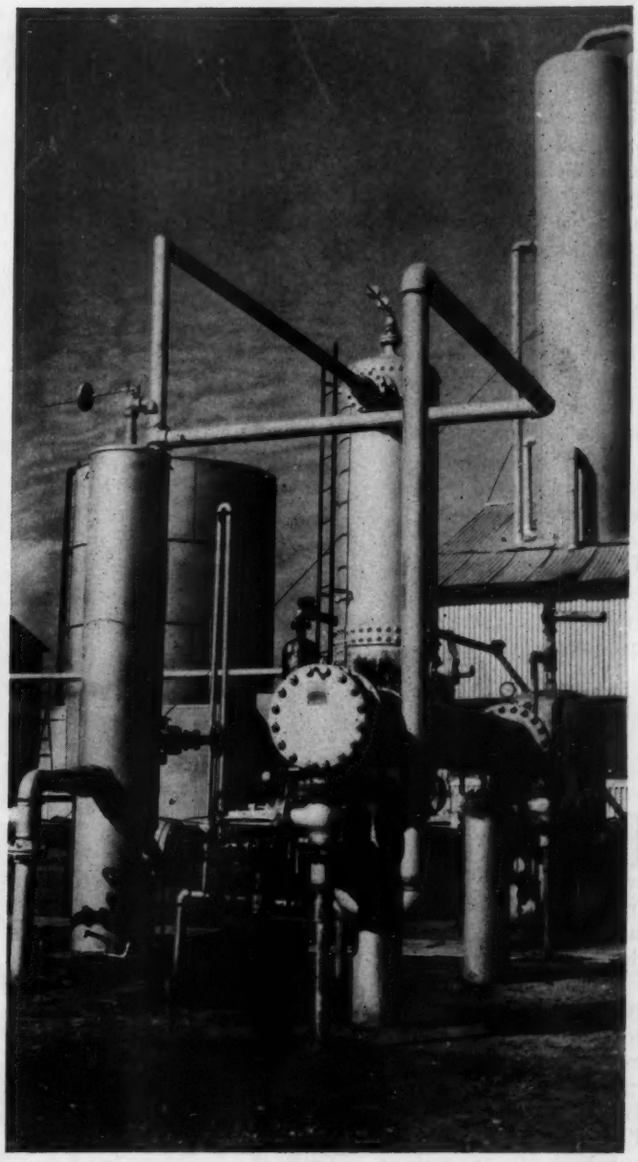
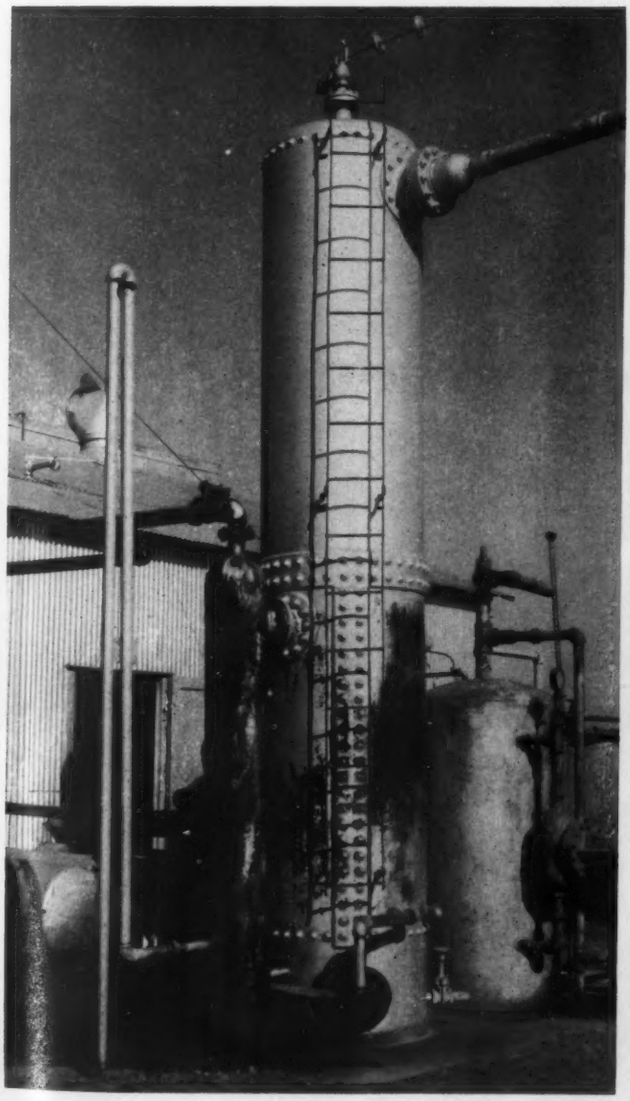
Lean Oil Drier Eliminates Moisture in Lines

IT was found that moisture in transmission lines from the McPherson, Kansas, compressor station was due to water being carried in the gasoline-plant residue, apparently from process steam in the distillation process. Provision for its removal was made through installation of a contact leg, where lean oil and dry natural gas mix, an oil-field type separator and water-cooled condenser, with a final scrubber for the gas before it is used as a fuel or returned to the absorption system.

The contact leg is a joint of 10-inch pipe with swedged fittings at each end, the lower for draining and the upper for introduction of hot lean oil. Two other connections are attached to the leg, one near the base for a dry gas inlet through a 2-inch pipe and the other a 4-inch outlet of gas and hot lean oil. The leg is attached to the separator by the 4-inch flanged fittings where the original inlet flange is located.



Gas then is cooled in this shell-and-tube section so that moisture and light ends can be deposited in the scrubber.



Contact of dry gas with lean absorption oil is provided in a contact leg beside the oil-field-type separator unit.

The original gas outlet on the oil and gas separator serves as the gas outlet, and the fluid outlet near the base returns the separated hot lean oil back to the system. Gas leaving the separator enters a shell-and-tube exchanger with water flowing through

the tubes to cool the gas before it enters the scrubber for separation of water and gas.

In operation, the apparatus takes lean oil from the still outlet, or from the first exchanger as conditions require (connections are made for either point of removal) and leads it to the contact leg where it flows downward through a continuation of the 4-inch pipe. This piece is made of sufficient length that the oil is discharged at a point approximately half the length of the contact leg. Dry natural gas is taken through a volume regulator and enters the leg at the base through the 2-inch connection to flow upward and contact the lean oil. The full stream of lean oil from the still, under process pressure of 35 pounds, flows to the leg, with gas and oil discharging to the oil and gas separator. Oil is removed from the base of the separator through a liquid-level controller and passes back immediately to the heat exchangers, and thence through the system to the surge tank, pump and lean-oil coolers.

The gas is cooled in the shell-and-tube section so that moisture and portions of the light ends of lean oil are condensed and are separated in the scrubber. This unit has an inclosed float controller, which actuates a diaphragm valve on the outlet piping, to allow the condensate, water and oil to flow to the plant skimmer pits where the oil is recovered.

Dry gas, containing a small amount of recoverable hydrocarbons, is either returned to the absorber or introduced into the plant fuel lines. The procedure recently has been to pick this gas up by the intake of the compressors used on field suction and pass it back with the wet gas to the absorbers, as the heat content is higher than required for gas-engine operation.

Tests of the lean oil before and after the installation of the system, conducted at frequent intervals reveal the following:

Gasoline saturation of lean oil.

Before	After
1.3 percent	0.0 percent

Water in Lean Oil

Before	After
.09 percent	0.00 percent

The absorption oil used in the gasoline plant has a gravity of 38 to 40°; an initial boiling point of 400° F. and an end point of 595° F. Oil has been used in the system with a gravity of 42°, and an initial boiling point of 350° F, and an end point of 550° F. No particular difference is observed in the behavior of either oil, and one is as susceptible to drying as the other. Operating temperatures are those normally carried on the distillation apparatus, and the pressures are those carried on the still. Frequently, due to varying load conditions, the pressure on the still drops to about 22 pounds, and as the load increases, it rises to about 35 pounds, where the normal pressures are maintained in winter operation.

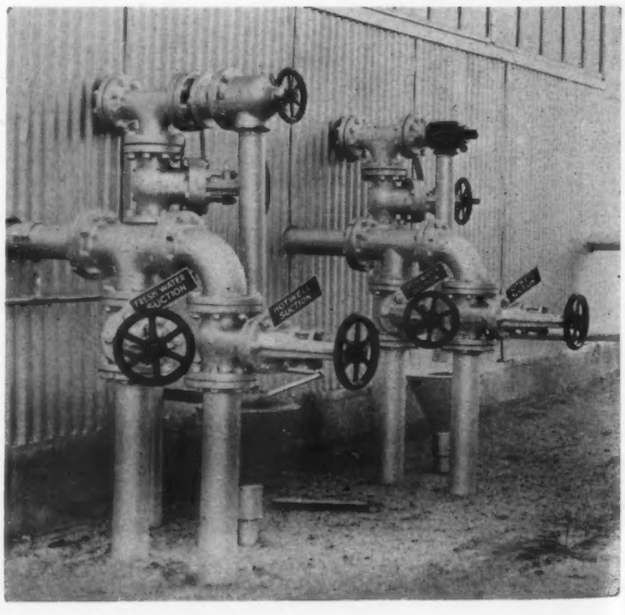
Prior to installing this unit, drips were blown frequently, but since it has been in continuous operation the line is drying rapidly, with drips containing a lesser amount of water as the distance increases from the plant. Gasoline plants operating in the field with residue returned to drilling and pumping wells can use such an apparatus successfully. The cost of construction may be what one wishes to spend, and the operation is automatic; using system pressure to handle lean oil to the contact leg and return to the exchangers, and, if the contacting gas contains a sufficiently low percentage of recoverable hydrocarbons, it may be injected into the fuel system or the field residue lines.

Tagged for Convenience

PLANTS that have been in operation for many years always have lines with which only the veteran employe is familiar. Sometimes even veterans hesitate before making a decision about which valve to close.

General Petroleum Corporation eliminates much guess work, particularly in boiler plants. When the boiler hot well is in the plant yard, some distance from the building, the make-up supply is automatically fed to the reservoir by a float-controlled valve that functions without difficulty in normal operation. The manifold which handles the water for the feed pumps has gate valves outside the building, and by opening a certain valve, hot-well water is delivered to the boilers. By changing this valve operation and opening another, fresh water is pumped instead, either to the feed water heater, or directly to the boilers.

So that the veteran employe, as well as the new man can make changes in the flow without guess work, tags are attached to all valves, in addition to the usual numeral for map reference, that are large and plainly marked. The tags are cut from light metal and painted black. A white border is placed around the outside, and white letters painted on the black background clearly indicate what this particular valve is used for. Holes punched in one end of the tags are used for slipping over a bonnet stud at a convenient place on the valve so the lettering will be in direct line of vision when the employe reaches for the gate wheel to make any change.



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Natural Gasoline Penalized by Low Motor Fuel Prices

By L. J. LOGAN

NATURAL gasoline continues to be produced primarily as a product for blending with refinery gasolines for improvement in both antiknock and volatility specifications.

Consequently, significant trends for natural gasoline have continued to be determined largely by developments in crude oil production and in the making and distribution of motor fuel.

Demand Growing

Output and consumption of natural gasoline normally trend upward, in line with the consistently growing production and use of petroleum and motor fuel; and interruptions of the rising trend usually occur only when unfavorable economic conditions interfere with normal use of oils.

After 1937, such interruptions occurred, the business recession of 1937-1938 having interfered with the growth of output and use of both crude oil and natural gasoline. Crude oil production declined somewhat in 1938 but then resumed the rise and approached the 1937 level in 1939. Natural gasoline production went on above the 1937 level in 1938, but declined toward the 1937 level in 1939. For the year 1939, therefore, both crude oil and natural gasoline were produced in roughly about the same quantities as in 1937. And this year is bringing further gains for both crude oil and natural gasoline.

The recent trends in production of the two materials are indicated in the accompanying figures.

Distribution of Natural Gasoline in the United States

(Figures indicate thousands of gallons and are from Bureau of Mines)

ITEM	1937	1938*
Production	2,065,434	2,113,314
Used at refineries†	1,596,294	1,621,704
Run through pipe lines in California	57,708	56,658
Exports‡	148,428	202,230
Shipped direct to consumers	143,640	137,970
Increase in Stocks	29,526	3,024
Losses	89,838	91,728
Total	2,065,434	2,113,314

* Unrevised.
† Includes quantities run through pipe lines east of California.
‡ As reported to the Bureau of Mines by manufacturers.

Year	Crude Oil Production (Thousands of Barrels)	Natural Gasoline Production (Thousands of Gallons)
1937	1,279,160	2,065,434
1938	1,214,355	2,156,574
1939	1,264,256	2,095,632
1940 (2 mos.)	+11.3%	+5.5%

If the current trends continue, 1940 will furnish a new high in production of crude oil, the 1937 output having been the greatest on record so far; and the production of natural gasoline will approach the records of 1929 and 1930, highest in the history of the industry. The output in 1929 was 2,233,653 thousands of gallons and that in 1930 was 2,210,455 thousands of gallons. If the gain of 5.5 percent over 1939 shown for early 1940 should be maintained, this year's production would be about 2,210,000 thousands of gallons.

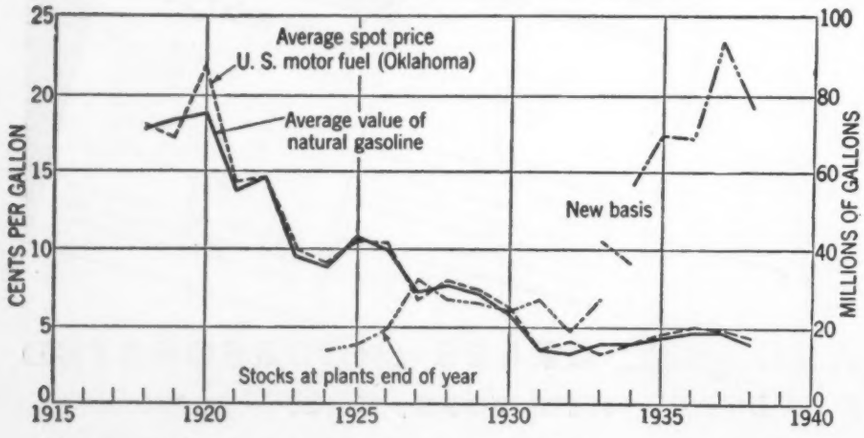
The prices of natural gasoline, except in California, now are exceptionally low, and the possibilities of profit for manufacturers have been greatly circumscribed, if not eliminated.

The weakness of the market for natural gasoline appears to be based mainly on the comparatively poor prevailing prices of motor fuel, rather than on conditions within the natural gasoline industry itself. Following an extraordinary build-up during the past winter, stocks of motor fuel are at an all-time peak, and prices are held down by the surplus. The production of natural gasoline has not been out of line with market demand, and stocks of that material are only 1 percent greater than a year ago, as a 20 percent gain at plants and terminals is largely offset by a 17 percent decrease at refineries.

The natural gasoline industry had a fairly profitable year in 1937, as production was above 2 billions

Value of Natural Gasoline Varies with Motor Fuel Prices

(Chart reproduced from *Minerals Yearbook, 1939*)



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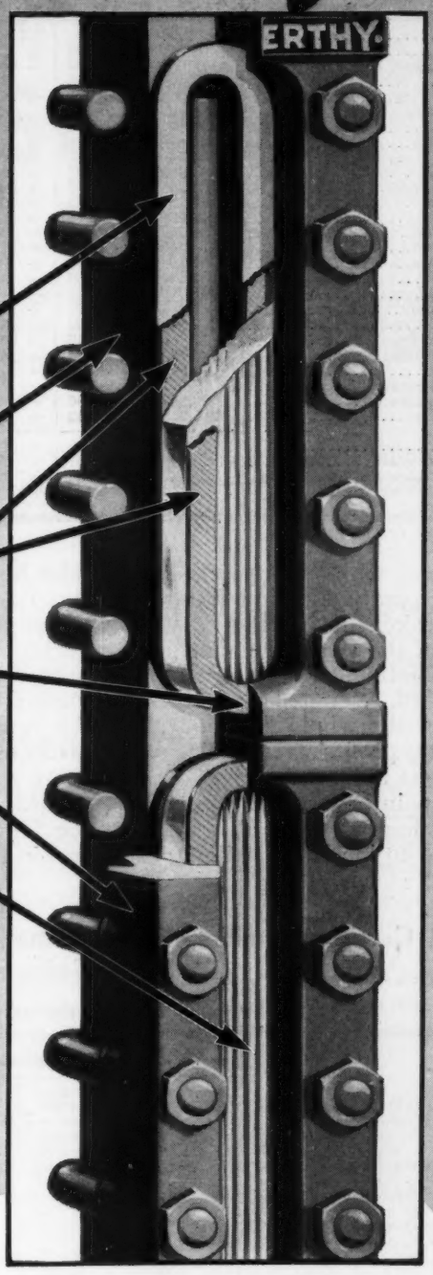

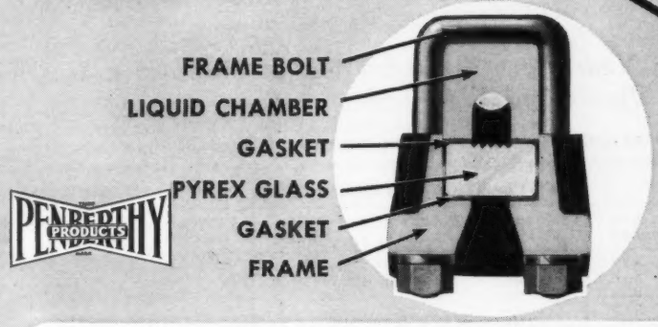

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Natural Gasoline Production Resumes Upward Trend in 1940 After Interruption in 1939

(Figures indicate thousands of gallons, and are from Bureau of Mines)

AREA	YEAR			FIRST TWO MONTHS		
	1938	1939	Percent Change	1939	1940	Percent Change
East Coast	.....	.....	.....	.....	.....	.....
Appalachian	68,541	70,268	+ 2.5	14,281	17,172	+ 20.3
Illinois, Michigan, Kentucky	13,057	15,264	+ 16.8	2,540	4,258	+ 67.5
Oklahoma	468,499	434,797	— 7.2	72,097	63,088	— 12.5
Oklahoma City	141,516	103,608	— 26.9	17,692	14,340	— 19.0
Osage County	55,861	51,027	— 8.6	7,901	7,807	— 1.2
Seminole	122,144	120,259	— 1.5	18,937	17,105	— 9.7
Rest of State	148,978	159,903	+ 7.4	27,567	23,836	— 13.5
Kansas	55,988	59,567	+ 6.4	10,341	11,656	+ 12.7
Texas	685,920	704,707	+ 2.8	103,876	128,625	+ 23.9
Gulf	65,266	85,137	+ 30.7	9,757	23,250	+138.5
East Texas	188,117	188,260	+ 0.07	27,331	26,339	— 3.6
Panhandle	249,968	242,020	— 3.2	38,264	43,699	+ 14.2
North Texas	26,699	26,473	— 0.8	4,163	4,572	+ 9.8
West Central	73,446	64,875	— 11.6	10,999	10,584	— 3.8
Rest of State	82,424	97,942	+ 18.8	13,362	20,181	+ 51.0
Louisiana	95,634	92,066	— 3.7	13,892	18,010	+ 30.4
Arkansas	25,648	24,631	— 4.0	4,014	3,249	— 19.0
Rocky Mountain	82,397	87,701	+ 6.5	13,198	13,267	+ 0.5
California	660,890	606,631	— 8.2	102,223	95,575	— 6.9
Huntington Beach	42,606	34,049	— 20.1	5,898	5,203	— 11.8
Kettleman Hills	186,780	156,484	— 16.1	29,775	20,519	— 31.0
Long Beach	92,675	86,745	— 6.4	13,819	14,280	+ 0.3
Santa Fe Springs	62,971	58,115	— 7.3	9,736	9,243	— 5.1
Ventura Avenue	60,642	61,996	+ 2.2	9,907	10,587	+ 6.8
Rest of State	215,216	209,242	— 2.8	33,088	35,743	+ 8.0
Total	2,156,574	2,095,632	— 2.8	336,462	354,900	+ 5.5
Daily average	5,908	5,741	— 2.8	5,703	5,915	+ 5.5
Total (thousands of barrels)	51,347	49,896	— 2.8	8,011	8,450	+ 5.5
Daily average	141	137	— 2.8	136	141	+ 5.5

of gallons, while prices received were comparatively good, although they weakened in the closing months of the year. The spot price of Mid-Continent natural gasoline, grade 26-70, averaged 3.69 cents a gallon for the whole year 1937.

In 1938, profits available to the natural gas industry were generally disappointing. Production and consumption of natural gasoline continued to increase, while stocks were held within reasonable limits. But the weakness of prices, which developed in late 1937, continued during the greater part of 1938, quotations having failed to advance materially until after the middle of the year. For 1938 as a whole, the Mid-Continent price averaged 2.74 cents a gallon. The low prices of natural gasoline in 1938 reflected the lagging of demand for motor fuel in the first half of the year, because of the business recession, the surplus stocks of motor fuel, and the resultant comparatively poor market conditions.

Although 1939 brought large fluctuations in the prices of natural gasoline, the year probably was on the whole more profitable than 1938, although not as good as 1937. Production was comparatively large, despite some reduction, and prices were better, on the average. Quotations were lowered sharply in the first few weeks of 1939, the average Mid-Continent price having dropped from 3.75 cents a gallon on January 1 to 2.50 cents by the middle of February. No improvement occurred until June, but in that month and July the average price rose to 3 cents. In August, when the oil fields of the Mid-Continent were shut in for two weeks, an extreme scarcity of natural gasoline developed, and within a few weeks the Mid-Continent average price jumped to 4.25 cents a gallon, at which level it stayed until December. In the final month, when prices normally should have been firm, because of large winter requirements for blending, the natural gasoline market tobogganed, along with a pronounced weakening of the motor fuel market, as stocks mounted precipitously. Within the month, prices lost all the ground that had

Natural Gasoline Stocks About Same as Year Ago, as Reduction at Refineries Is Offset by Gains at Plants and Terminals

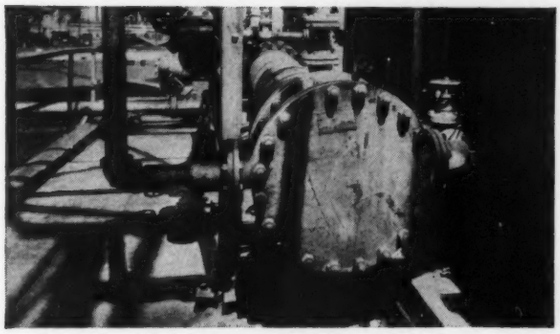
(Figures indicate thousands of gallons, and are from Bureau of Mines)

AREA	AT REFINERIES			AT PLANTS AND TERMINALS			TOTAL STOCKS		
	February 28, 1939	February 29, 1940	Percent Change	February 28, 1939	February 29, 1940	Percent Change	February 28, 1939	February 29, 1940	Percent Change
East Coast	2,898	4,830	+ 66.7	.....	.....	.....	2,898	4,830	+ 66.7
Appalachian	168	252	+ 50.0	8,522	6,818	— 20.0	8,690	7,070	— 18.7
Illinois, Michigan, Kentucky	2,184	2,646	+ 21.3	554	554	.....	2,738	3,200	+ 16.8
Oklahoma	1,218	2,310	+ 89.5	17,876	17,386	— 2.7	19,094	19,696	+ 31.4
Oklahoma City	*	*	.....	7,898	5,402	— 31.6	*	*	.....
Osage County	*	*	.....	2,852	4,059	+ 42.2	*	*	.....
Seminole	*	*	.....	1,917	4,265	+123.0	*	*	.....
Rest of State	*	*	.....	5,209	3,660	— 29.8	*	*	.....
Kansas	42	126	+200.0	673	628	— 6.7	715	754	+ 5.4
Texas	5,040	6,594	+ 30.9	61,095	82,268	+ 34.2	66,135	88,862	+ 34.2
Gulf	3,990	5,964	+ 49.5	32,910	43,439	+ 32.0	36,900	49,403	+ 34.0
East Texas	*	*	.....	425	2,156	+408.0	*	*	.....
Panhandle	*	*	.....	23,551	30,061	+ 27.8	*	*	.....
North Texas	*	*	.....	571	1,151	+101.1	*	*	.....
West Central	*	*	.....	1,928	3,414	+ 77.2	*	*	.....
Rest of State	*	*	.....	1,710	2,047	+ 19.7	*	*	.....
Louisiana	42	210	+400.0	874	929	+ 6.3	916	1,139	+ 24.3
Arkansas	84	630	+650.0	310	322	+ 3.9	394	952	+ 14.2
Rocky Mountain	672	1,512	+125.0	1,133	830	— 26.7	1,805	2,342	+ 29.8
California	92,022	67,494	— 26.7	2,329	3,455	+ 48.2	94,351	70,949	— 24.8
Huntington Beach	*	*	.....	*	*	.....	*	*	.....
Kettleman Hills	*	*	.....	*	*	.....	*	*	.....
Long Beach	*	*	.....	*	*	.....	*	*	.....
Santa Fe Springs	*	*	.....	*	*	.....	*	*	.....
Ventura Avenue	*	*	.....	*	*	.....	*	*	.....
Rest of State	*	*	.....	*	*	.....	*	*	.....
Total	104,370	86,604	— 17.0	93,366	113,190	+ 20.2	197,736	199,794	+ 1.0
Daily average	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total (thousands of bbls.)	2,485	2,062	— 17.0	2,223	2,695	+ 20.2	4,708	4,757	+ 1.0
Daily average	.....	.....	.....	.....	.....	.....	.....	.....	.....

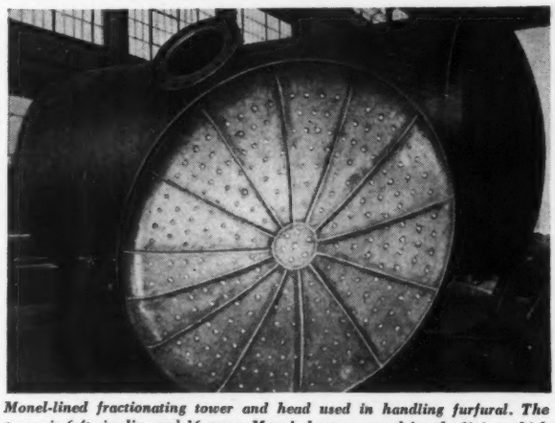
* Not available.

3 ECONOMICAL WAYS

TO PROTECT NEW OR OLD EQUIPMENT AGAINST CORROSION...



Naphtha cooler with shell constructed of ¼" Nickel-Clad plate with 20% Nickel cladding. The cooler handles naphtha overhead from crude oil. The naphtha contains sulfides and chlorides with traces of phenol.



Monel-lined fractionating tower and head used in handling furfural. The tower is 6 ft. in dia. and 16 gauge Monel sheet was used for the lining which was plug welded to the steel on 6" centers. Built by Southwest Welding and Manufacturing Company, Alhambra, California.

Interior view of a 6 ft. I.D. by 17 ft. long accumulator drum with the head lined with 3/32" Monel sheet applied by plug welding and seam welding. Built by Black, Sivalls, and Bryson, Inc., Oklahoma City, Oklahoma.

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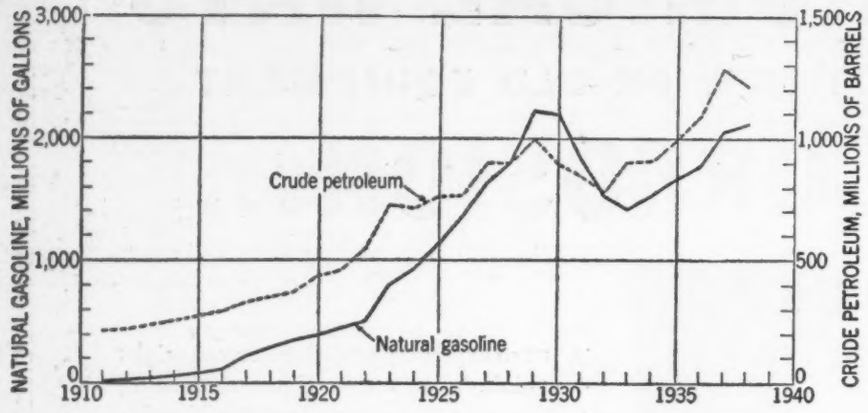
Annual Production of Natural Gasoline Closely Follows Trend of Crude Petroleum Output

(Chart reproduced from *Minerals Yearbook, 1939*)



been gained since June, the average Mid-Continent quotation having been about 2.50 cents a gallon as the year closed. For 1939 as a whole, the average price was around 3.15 cents a gallon.

From the 2.50-cent level of January 1, the average Mid-Continent price declined to 2 cents a gallon in the initial month of 1940; and although the latter price held through February and the first half of March, there was a further decline by April 1 to 1.50 cents a gallon. Late in April that extremely low price still prevailed. For the first four months of 1940, the average price has been only about 1.87 cents a gallon. In tabular form, the history of the average Mid-Continent price of natural gasoline has been as follows:

Year	Cents Per Gallon at Plants
1937	3.69
1938	2.74
1939 (estimated)	3.15
1940 (4 months, estimated)	1.87

In contrast with the erratic and unstable market for natural gasoline in the Mid-Continent, that in California has been comparatively firm, and prices have been generally satisfactory. In the first half of 1939 the price f.o.b. plants in the Los Angeles basin ranged between 6 and 6.75 cents a gallon, and in the latter half of the year, the range was between 5.50 and 6.25 cents. In the first four months of 1940, quotations have been maintained steadily at 6 to 6.25 cents a gallon.

Recycling Plants

The natural gasoline industry still is in the process of making a place for added productive capacity, provided through construction of recycling plants, mainly in Texas and Louisiana. There are now about a dozen of those plants in Texas, including those at Cayuga, Long Lake, and Grapeland, in Eastern Texas, at Bammel, Old Ocean and others on the Gulf Coast, and the several plants in the Corpus Christi area. Louisiana has several plants, including that at Cotton Valley. Altogether, those plants have provided a substantial increase in the United States capacity for making natural gasoline, as even a small recycling plant can process 20 or 25 millions of cubic feet of natural gas a day, obtaining around 20,000 gallons, or 500 barrels, daily of natural gasoline, the yield being about 8/10 of a gallon per thousand feet of natural gas, which is somewhat less than the average yield from the ordinary natural gasoline plant.

Recovering gasoline from distillate wells, while returning the residue gas to the producing formations, the recycling plants necessarily are located in high-pressure fields that produce substantial proportions of distillate along with gas.

The new recycling plants have been instrumental in making Texas the No. 1 natural gasoline producing state. In 1939 Texas accounted for one third of the United States production, having turned out 3 percent more than in 1938; and the state's output still trends upward. California, formerly the largest producing state, furnished somewhat less than a third of the national output in 1939, having registered an 8 percent decrease from 1938, and in 1940 the trend has continued downward. Oklahoma, third largest producing state, yielded a little over one fifth of the country's production in 1939, but output was down 7 percent from 1938, and this year has brought a further decline. The three leading states account for 83 percent of the total United States production of natural gasoline.

Natural Gasoline Production in United States, by Years

(Source: Bureau of Mines)

YEAR	Number of Operators	Number of Natural Gasoline Plants Operating	Natural Gas Processed (Millions of Cubic Feet)	Natural Gasoline Production			Average Yield of Gasoline Per Thousand Cubic Feet of Gas Processed (Gallons)
				Quantity (Thousands of Gallons)	Value at Plants (Thousands of Dollars)	Price Per Gallon (Cents)	
1911	132	176	2,476	7,426	532	7.16	3.000
1912	186	250	332	12,081	1,157	9.58	2.577
1913	232	341	9,889	24,061	2,458	10.22	2.433
1914	254	386	16,895	42,653	3,106	7.28	2.525
1915	287	414	24,064	65,365	5,151	7.88	2.716
1916	460	596	208,705	103,493	14,331	13.85	0.496
1917	750	886	429,288	217,884	40,189	18.45	0.508
1918	503	1,004	449,109	282,536	50,364	17.83	0.629
1919	611	1,191	480,404	351,535	64,197	18.26	0.732
1920	576	1,154	496,431	384,744	71,788	18.66	0.775
1921	458	1,056	479,618	449,934	61,815	13.74	0.938
1922	402	917	545,139	505,832	72,711	14.37	0.928
1923	455	1,067	875,711	816,226	77,268	9.47	0.932
1924	457	1,096	1,016,276	933,861	82,233	8.81	0.919
1925	449	1,080	1,040,369	1,127,437	120,378	10.68	1.084
1926	389	1,101	1,206,275	1,363,057	136,408	10.01	1.130
1927	393	1,118	1,341,233	1,641,125	118,686	7.23	1.224
1928	368	1,077	1,473,414	1,814,008	138,941	7.66	1.231
1929	363	1,086	1,959,267	2,233,653	158,406	7.09	1.140
1930	349	1,034	2,088,748	2,210,455	128,155	5.80	1.058
1931	323	936	1,790,094	1,831,886	63,727	3.48	1.023
1932	301	829	1,499,737	1,523,775	49,240	3.23	1.016
1933	290	778	1,551,444	1,419,975	54,364	3.83	0.915
1934	288	766	1,776,172	1,535,360	60,523	3.94	0.864
1935	278	715	1,822,000	1,651,986	70,940	4.30	0.910
1936	263	700	1,815,000	1,796,340	84,572	4.70	0.990
1937	249	696	2,108,800	2,065,434	97,125	4.70	0.980
1938	....	....	2,150,000	2,156,574	78,195	3.70	1.000
1939	....	....	.....	2,095,632	.....	....	.....

BUY PUMPING RESULTS

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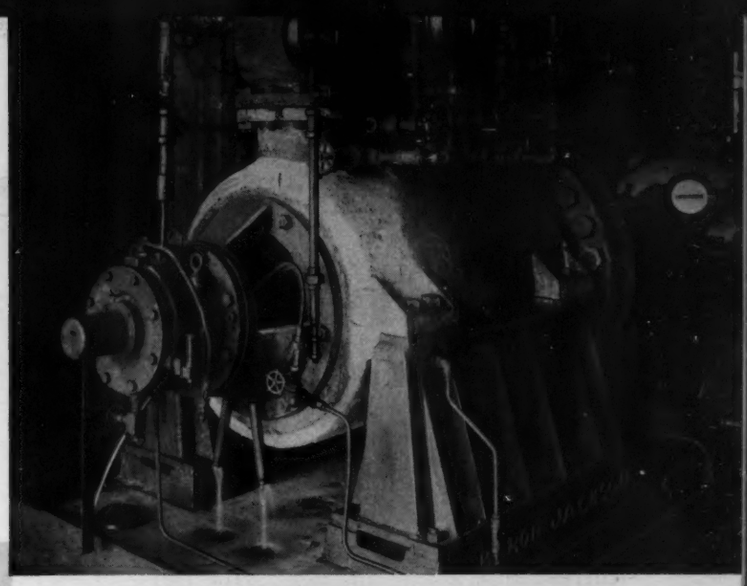

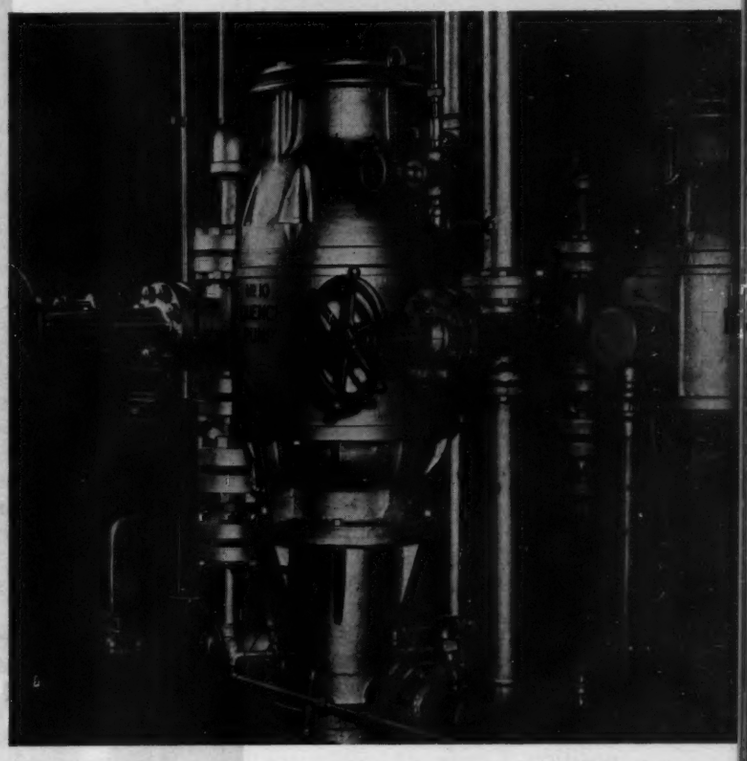

THE HOUDRY PROCESS presented an interesting pumping problem involving circulation of the heat transfer agent to the catalytic chests. The heat transfer agent used is a mixture of salts, molten, and at temperatures up to 850° F. These molten salts are circulated to the catalytic chests for proper heat control. Structural requirements indicated the vertical type of pump, with the pump enclosed in a collecting chamber at the temperature of the salts, and the driver external to this chamber. The unit required an extremely long shaft, and the matter of expansion strains was highly important. As pumps are for circulation rather than for operation against high pressures, the heads are very low, but astonishingly large circulating capacities are required.

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Upper picture shows one of eight Byron Jackson Hot Oil Charging Pumps in service at Atlantic Oil Company's Atreco Refinery, where a total of 33 Byron Jackson Pumps are in operation. Lower picture shows Byron Jackson HYDROPRESS Pumps used in the Thermal Cracking Unit at Sun Oil Company's Plant as Naphtha Quench Pumps, discharging 50 g.p.m. at a temperature of 140 degrees F., against a discharge pressure of 900 pounds per square inch. When capacities as low as 15 g.p.m. and heads as high as 6000 feet are your problem, it will pay you to investigate the HYDROPRESS.

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CENTRIFUGAL PUMPS FOR EVERY SERVICE

Adjusted Refining Yields Needed to Balance Fuel Sales

By FRED VAN COVERN
Director, Department of Statistics, American Petroleum Institute

NOT enough consideration has been given to the possible effects of the actual progress of consumptive trends, particularly the rapid growth of furnace oil sales until it has become established as a principal petroleum product, along with gasoline. The accompanying study of this important situation, which was presented at the Interstate Oil Compact Commission meeting in Oklahoma City on April 5, 1940, shows how the furnace oil market has developed, how it has created unfavorable inventory relationships and discusses methods that might be used to cure the condition.

IN ANY attempt to analyse the current situation in the petroleum industry, one is confronted with the necessity of having to net the effect of a number of pressures exerting their forces in different directions and varying degrees.

From the point of view of product demand, the industry seems to be in a good position. During 1939 the total demand for motor fuel increased 4.2 percent. About 11 percent more light fuel oils were sold than in 1938, and residual fuel oil shipments also increased about 11 percent. More lubricating oils and greases were sold than ever before, and the total demand for crude oil and all refined products was greater by about 6.5 percent.

These trends continued into January and while actual figures are not yet available for February and March, nothing of importance seems to have occurred to change the general tendencies, but more detailed reference will be made to the export situation later.

From the point of view of inventories we find some products in firm condition, some in even strong position. Crude oil stocks are less than a year ago. Continued increases have occurred during the past several weeks, however, and have brought the current total close to 250,000,000 barrels—about 20,000,000 above the 1939 low. Light fuel oil stocks are down and so are heavy fuels. Kerosene stocks are in good position and lubricant inventories are also less than a year ago, but finished and unfinished gasoline stocks are at an all-time high, and gasoline is still the industry's principal product. It is very interesting, I think, to compare present inventories by districts with those of a year ago, and particularly interesting to make these comparisons in the light of the home-heating fuel oil situation of the past winter and also the current gasoline export situation. Of the 14,000,000 barrels greater inventories indicated in Table 1, slightly over 6,000,000 are in the Texas Gulf Coast area. Not quite 5,000,000 barrels are in the Interior region, notably in the Indiana-Illinois, and to a considerably lesser extent, the Oklahoma-Kansas-Missouri district, and about 2,000,000 are in California.

TABLE 1

Finished and Unfinished Gasoline Inventories (Barrels of 42 Gallons)

DISTRICT	Mar. 31, 1939 U.S.B. of M.	Sept. 30, 1939 U.S.B. of M.	Mar. 30, 1940 (Estimated)
East Coast	22,639,000	18,653,000	22,200,000
Louisiana Gulf	2,682,000	1,988,000	3,500,000
Texas Gulf	11,790,000	11,439,000	17,900,000
	37,111,000	32,080,000	43,600,000
Indiana-Illinois-Kentucky	15,780,000	11,778,000	19,600,000
Oklahoma-Kansas-Missouri	8,303,000	6,007,000	9,200,000
Inland Texas	2,351,000	1,919,000	2,200,000
North Louisiana-Arkansas	711,000	488,000	1,000,000
	27,145,000	20,192,000	32,000,000
Appalachian	3,672,000	2,715,000	4,400,000
Rocky Mountain	2,271,000	1,376,000	2,100,000
EAST OF CALIFORNIA	70,199,000	56,363,000	82,100,000
California	16,922,000	14,629,000	19,300,000
TOTAL UNITED STATES	87,121,000	70,992,000	101,400,000

Furnace Oil Becomes Factor

A condition which had already been of considerable interest to the industry during recent years, but even so, without fulfilling all the possibilities involved, seems during the past winter to have developed its full potentialities. I am referring to the rapid growth in the number of home-heating oil burners in use and the fuel which they consume and the number of automotive vehicles and the growth in their consumption of gasoline, in relation to the yield of these two products from a barrel of crude oil, and the industry's operating practices with respect thereto.

Time was when this was a kerosene industry and gasoline a nuisance product. With the advent of the internal - combustion engine gasoline became the principal product, but more recently furnace oils seem to have pressed for greater recognition. Obviously the industry has not followed any coordinated policy with respect to these changing trends, and while it may not be correct to say that operators did not realize the full potentialities involved, it does seem as though not enough consideration has been given to the possible effects of the actual progress of events.

There are still many important elements in the industry who seem to think of it as one in which gasoline, or motor fuel, is the principal product, probably because they do not have furnace oils for sale. Others seem to have followed the

AN UPHEAVAL not foretold . . . .

The astrologers searched the stars . . . foretelling the future in the light of their then present knowledge.

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REPRESENTATIVES THROUGHOUT THE WORLD

TABLE 2

Motor Fuel and Gas Oil and Distillate Fuel Demand, Number of Burners and Yields

YEAR	Motor Fuel Demand (Barrels)	Gas Oil & Distillate Fuel Demand (Barrels)	Number of Burners In Use (End of Year)	Yield from Motor Fuel Percent	Crude Oil Gas & Dis. Fuels Percent
1933	409,815,000	76,172,000	913,000	43.69	9.16
1934	435,025,000	89,330,000	1,014,000	43.41	10.60
1935	465,423,000	102,277,000	1,155,000	44.19	10.38
1936	510,252,000	123,205,000	1,356,000	44.08	11.78
1937	557,658,000	146,970,000	1,544,000	43.92	12.40
1938	573,112,000	147,090,000	1,658,000	44.30	13.03
1939	597,116,000	163,956,000	1,905,000	44.89	13.06
Increase	45.7%	115.2%	108.7%	.....	.....

policy of disposing of only that which is incidental to the production of gasoline, while the more general practice seems to have been to establish furnace oil as a principal product, along with gasoline, until the home-heating oil market has grown to such an extent that it now demands an important segment of each barrel of crude processed.

Yield Flexibility Needed

That the burning of petroleum oils in home-heating units is proper economic use of such oils can hardly be denied. Their use seems, however, to have outgrown or at least to have increased faster than the ability to build into refineries the necessary flexibility as between the required production of gasoline and these light fuels; or, is their rapid growth and the present situation the logical outcome of the industry's operating practices of the past in conjunction with the relationship which has existed between the price of the two as finished products, and the economic worth of cracking stock. Regardless of how it was brought about, the industry has, nevertheless, with it today the very important problem of how more nearly to balance their combined supply and demand. And, it can hardly be denied that as any given portion of the barrel of crude oil moves towards principal product distinction, that trend carries with it the responsibility of assuming, for that particular fraction, a corresponding liability in relation to the cost of the raw material required.

Perhaps the flexibility necessary does exist within the limits of present facilities and I will come to that again later. Is it merely a question of shifting yields, or is it more complicated than that? Does the question of octane rating of gasoline enter? Should calculations of crude oil requirements be placed upon a combination yield basis? It may be that the situation merely requires a change in method of operation, and the building up during the summer months of larger inventories of these fuels before the winter period sets in. Up to the present time the industry seems to have chosen to make furnace oils as the requirements of the season dictated rather than build up inventories in anticipation of future sales.

From the figures contained in Table 2 one may note how the growth in the demand for motor fuel and furnace oils has progressed in relation to each other and in relation to the yields of these products from a barrel of crude oil.

It is readily apparent from a study of the figures that the number of home-heating oil burners in use has grown tremendously over the last several years, to such an extent, in fact, that while gasoline increased about 45 percent during the six-year period from 1933 to 1939, gas oil and distillate fuel oil demand, of which furnace oils comprise the largest single item, increased more than twice that much, or about 115 percent.

Further light is thrown on this situation when a study is made of the inventories of these light fuels at the beginning of the past several winters. In spite of an increase of over 17 percent in the number of burners at the end of 1936, compared with 1935, the industry entered the 1936-1937 winter season with only about 3,500,000 barrels greater light fuel inventories; in the face of an additional 14 percent increase in burners in 1937 stocks of these oils were less entering the 1937-1938 winter than in the previous year. The situation was not as bad in relation at the beginning of the 1938-1939 winter but at the opening of the past heating season stocks of furnace oils actually were less in comparison with those of a year before even in face of another increase in the number of burners of close to 15 percent. In other words, the figures indicate that on September 30, 1939, inventories entering the winter season were only 24 percent higher than on September 30, 1935, in spite of an increase in the number of burners to be supplied of about 65 percent, and these figures become particularly significant when one realizes the relationship between a home-heating burner and the average automotive unit. My estimates show that the average burner will consume approximately 2300 gallons in a heating season (September to May) while the average automotive unit consumes only about 730 gallons of gasoline a year (1939 calculated average). If there is any doubt as to what such conditions mean with respect to gasoline inventories, the figures in the last two columns of Table 3 are very enlightening.

Of course, it is impossible to forecast the weather and winter temperatures, and that is where one of the greatest difficulties lies. The records that are presently available show that the average temperatures on a degree-day basis for the first five months of this winter season were about 2 percent colder than normally might have been expected, yet 13 percent colder than during the 1938-1939 winter, which heating season continued a trend that began two years earlier in that the three winters prior to the present one were less than normally cold when

TABLE 3

Light Fuel Inventories, Number of Burners and Motor Fuel Comparisons

YEAR	September 30, Gas Oil & Distillate Fuel Inventories (Barrels)	Number of Home-Heating Oil Burners in Use		Finished & Unfinished Gasoline	
		End of Year	Percent Increase	Economic Requirements March 31, Following Year (Barrels)	Actual Inventories (Barrels)
1935	24,272,000	1,155,000	13.9	70,000,000	74,485,000
1936	27,871,000	1,356,000	17.4	73,500,000	81,651,000
1937	27,020,000	1,544,000	13.9	75,000,000	92,277,000
1938	30,860,000	1,658,000	7.4	78,500,000	87,121,000
1939	30,018,000	1,905,000	14.9	82,000,000	*101,000,000
4-Year Increase	.....	64.9%	.....	.....	.....

* March 30, 1940 estimated.

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TABLE 4

Percentage Yield of Products From Crude Oil

YEAR	QUARTERS ENDED							
	Gas Oil & Distillate Fuels				Gasoline (Straight-Run & Cracked)			
	June	Sept.	Dec.	Following March	June	Sept.	Dec.	Following March
1935	9.95	10.18	10.88	12.64	44.04	44.80	44.37	42.73
1936	11.09	11.24	12.20	12.99	44.36	44.62	44.50	44.21
1937	11.22	12.09	13.32	13.59	44.00	43.35	44.16	43.25
1938	11.95	12.90	13.67	14.10	44.05	45.06	44.76	44.74
1939	12.65	12.16	13.43	....	44.56	44.87	45.34	....

measured on a degree-day basis.

Statistics on burner sales are readily available and the number of burners that probably will be in use during a given winter is susceptible of fairly easy calculation, but temperatures can only be related to expected normals. It does seem, however, that greater inventories of these oils in relation to the number of burners in use and normal winters are indicated at the opening of coming winter seasons than have been carried in the past. About 60-62 percent of the demand for gas and distillate fuel oils comes during the six-months period from October to March, yet the greatest buildup of inventories of these products during the past five summer seasons was about 12,000,000 barrels in 1936, while the average of the five has been about 10,000,0000. Not only has the industry as a whole chosen to more or less produce these amounts as required but also seemingly, at least, has it elected to retain a fairly uniform gasoline yield, producing approximately 3½ barrels of gasoline to every barrel of light fuels produced. This did not hold during the 1935-1936 winter but seems to have been the practice during more recent years. Table 4 shows a comparison of the yields for the entire country by quarters during the past five years. It will be noted that distillate yields have always increased during the winter season but gasoline yields have not as a general rule shown corresponding declines, at least, not for the industry as a whole.

Up until now we have been talking about this from more or less of a nation-wide point of view, but it can be narrowed still further. The latest information available shows that about 58 percent of all the home-heating oils used in the United States are consumed in the New England and Middle-Atlantic states. An additional 29 percent are used in the North Central States. In all other areas East of California another 9 percent is consumed, and on the Pacific Coast about 4½ percent.

It is interesting to take another look at the gasoline inventories by refining districts in the light of the statements just made. The areas that supply the greater portions of the heating oils are the areas in which gasoline inventories show the greatest increases, and the only areas in which there is a rather well-defined tendency towards a shifting in yields as between gasoline and light fuel, particularly during the winter season. This has not been as definitely discernible during the summer months, however.

Oklahoma-Kansas, Inland Texas and other districts do not supply any very great portion of the heating-oil market, but neither have they increased their gasoline stocks as much as the others.

California's problem has not been one in which large quantities of heating oils have had to be supplied though it is a fact that the consumption of furnace oils on the Pacific Coast has experienced a relatively large increase during the last few years.

All will agree, I believe, that too much gasoline was produced during the past winter and probably most will agree that the principal reason was the necessity to supply the requirements of furnace oils over and above the possibilities of storage withdrawals.

To what extent the export situation may have entered the calculations of refiners is, of course, difficult to say but it may have been another factor, particularly on the Texas Gulf Coast.

Total exports of crude oil and all petroleum products to all foreign countries during the first five months of the war have actually been less than those of the previous comparable period. Gasoline

TABLE 6

Export Shipments of Crude Oil and Principal Refined Products
(Barrels 42)

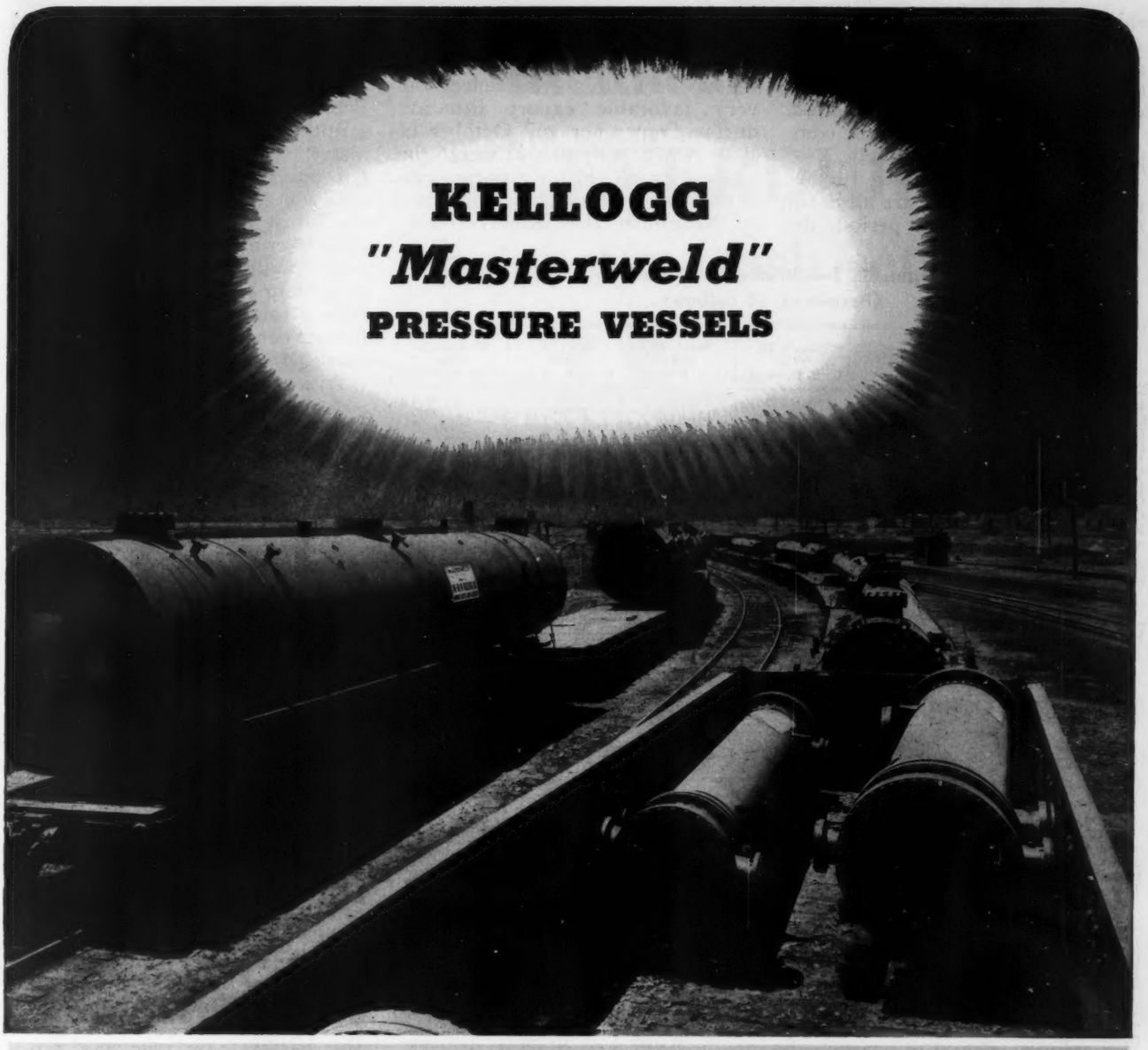
PRODUCT	Five-Month Period Ending			Late Developments		
	January, 1939	January, 1940	Percentage Change	February, 1939	February, 1940	Percentage Change
Crude Oil	27,319,000	28,053,000	+ 2.7	4,810,000	3,327,000	—30.8
Gasoline	20,813,000	15,645,000	—24.8	2,909,000	1,903,000	—34.6
Kerosene	3,433,000	3,294,000	— 4.0	532,000	299,000	—43.8
Light Fuels	10,360,000	12,434,000	+20.0	2,131,000	1,223,000	—42.6
Heavy Fuels	7,709,000	6,495,000	—15.7	925,000	737,000	—20.3
Lubricants	3,793,000	5,565,000	+46.7	680,000	1,090,000	+60.3
Total principal Refined Prods.	46,108,000	43,433,000	— 5.8	7,177,000	5,252,000	—26.8
Total Exports indicated	73,427,000	71,486,000	— 2.6	11,987,000	8,579,000	—28.4

TABLE 5

Percentages of U. S. Domestic Demand for Gas Oil and Distillate Fuel Oil and Domestic Heating Oil By Geographical Subdivisions

(Compiled from Bureau of Mines.)

Sub-divisions:	Gas Oil & Distillate Fuel Oil			Domestic Heating Oil		
	Percentage of U. S.			Percentage of U. S.		
	1936	1937	1938	1936	1937	1938
New England	13.8	14.9	14.9	18.5	18.7	18.5
Middle-Atlantic	33.6	33.5	34.1	40.4	39.8	39.6
Sub-total	47.4	48.4	49.0	58.9	58.5	58.1
North Central	21.5	24.0	24.8	28.7	28.5	28.7
Sub-total	68.9	72.4	73.8	87.6	87.0	86.8
Other States: East of Pacific Coast	16.6	* 11.4	12.3	9.3	9.3	8.8
TOTAL EAST OF CALIFORNIA	85.5	83.8	86.1	96.9	96.3	95.6
Pacific Coast	14.5	16.2	13.9	3.1	3.7	4.4
TOTAL UNITED STATES	100.0	100.0	100.0	100.0	100.0	100.0



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shipments abroad have been considerably less; lubricants are up as are light fuels; heavy fuels show a decline. Crude oil exports also were up slightly during this period.

Table 6 shows five months comparative figures by products.

And, it might be stated further that when the records are all in for the first seven-month period, the relationships indicated will be even less favorable.

It may be well to point out that the above figures even reflect the very favorable export situation during September and October of 1939 when shipments were the highest on record for any September-October period. It was not until November that exports really began to respond to war conditions and since that time the decline has been accelerated greatly. Preliminary calculations for the month of February made from the manuscripts of the Department of Commerce (official published figures not having been available at the time of this compilation) reveal the latest definite trends. A decline in crude oil exports of 31 percent combined with a fall of 27 percent in refined products to register a total loss of 28 percent in foreign demand upon the American petroleum industry during that month. Only lubricants have so far thrived on the occurrence of hostilities. These latest developments are presented in Table 6 also.

Appendix I—Stocks of Crude Oil
(Barrels of 42 Gallons)

GRADE	March 31, 1939 U. S. B. of M.	Sept. 30, 1939 U. S. B. of M.	Oct. 21, 1939 U. S. B. of M.	March 23, 1940 U. S. B. of M.
Pennsylvania Grade	5,542,000	5,124,000	5,100,000	4,344,000
Other Appalachian	1,295,000	1,388,000	1,374,000	1,232,000
Lima, N. E. Indiana-Michigan	1,943,000	2,062,000	1,823,000	1,651,000
Illinois, S. W. Indiana	12,705,000	16,584,000	15,641,000	18,820,000
North Louisiana and Arkansas	8,975,000	6,776,000	6,427,000	6,948,000
West Texas and S. E. New Mexico	23,727,000	19,533,000	19,213,000	23,034,000
East Texas	21,418,000	13,500,000	13,813,000	16,829,000
Other Mid-Continent	107,940,000	88,803,000	86,955,000	93,211,000
Gulf Coast	29,790,00	23,078,000	22,909,000	25,744,000
Rocky Mountain	20,827,000	18,235,000	17,782,000	17,270,000
EAST OF CALIFORNIA	234,162,000	195,083,000	191,037,000	209,083,000
California	39,383,000	37,372,000	35,774,000	36,080,000
Total Domestic Crude	273,545,000	232,455,000	226,811,000	245,163,000
Foreign Crude	2,810,000	2,100,000	2,316,000	2,238,000
Total all Stocks of Crude Oil in the United States	276,355,000	234,555,000	229,127,000	247,401,000

Appendix II—Stocks of Gas Oil and Distillate
(Barrels of 42 Gallons)

DISTRICT	March 31, 1939 U.S.B. of M.	Sept. 30, 1939 U.S.B. of M.	March 30, 1940 Estimated
East Coast	2,635,000	6,400,000	2,000,000
Louisiana Gulf	787,000	840,000	700,000
Texas Gulf	3,227,000	6,076,000	2,800,000
	6,649,000	13,316,000	5,500,000
Indiana, Illinois, Kentucky	1,926,000	3,917,000	1,800,000
Oklahoma, Kansas, Missouri	1,122,000	1,787,000	1,300,000
Inland Texas	273,000	363,000	200,000
North Louisiana and Arkansas	186,000	214,000	200,000
	3,507,000	6,281,000	3,500,000
Appalachian	184,000	214,000	200,000
Rocky Mountain	215,000	227,000	200,000
EAST OF CALIFORNIA	10,555,000	20,038,000	9,400,000
California	9,560,000	9,980,000	9,200,000
Total United States	20,115,000	30,018,000	18,600,000

Appendix III—Stocks of Residual Fuel Oil
(Barrels of 42 Gallons)

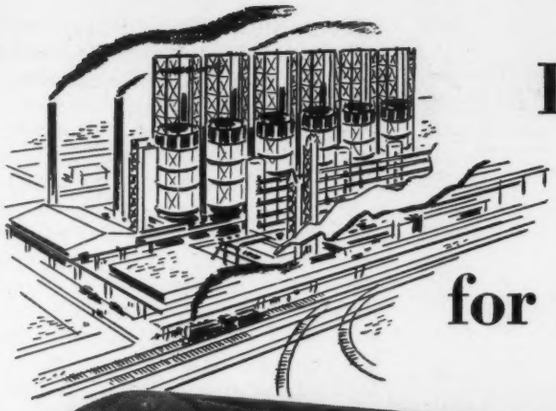
DISTRICT	March 31, 1939 U.S.B. of M.	Sept. 30, 1939 U.S.B. of M.	March 30, 1940 Estimated
East Coast	3,842,000	5,724,000	3,800,000
Louisiana Gulf	696,000	2,110,000	800,000
Texas Gulf	4,972,000	8,163,000	5,600,000
	9,510,000	15,997,000	10,200,000
Indiana, Illinois, Kentucky	2,728,000	2,843,000	3,400,000
Oklahoma, Kansas, Missouri	3,335,000	3,285,000	2,200,000
Inland Texas	2,003,000	2,460,000	1,600,000
North Louisiana and Arkansas	514,000	605,000	400,000
	8,580,000	9,193,000	7,600,000
Appalachian	582,000	417,000	700,000
Rocky Mountain	616,000	602,000	600,000
EAST OF CALIFORNIA	19,288,000	26,209,000	19,100,000
California	86,294,000	82,927,000	78,900,000
Total United States	105,582,000	109,136,000	98,000,000

Should Liquidate Gasoline Stock

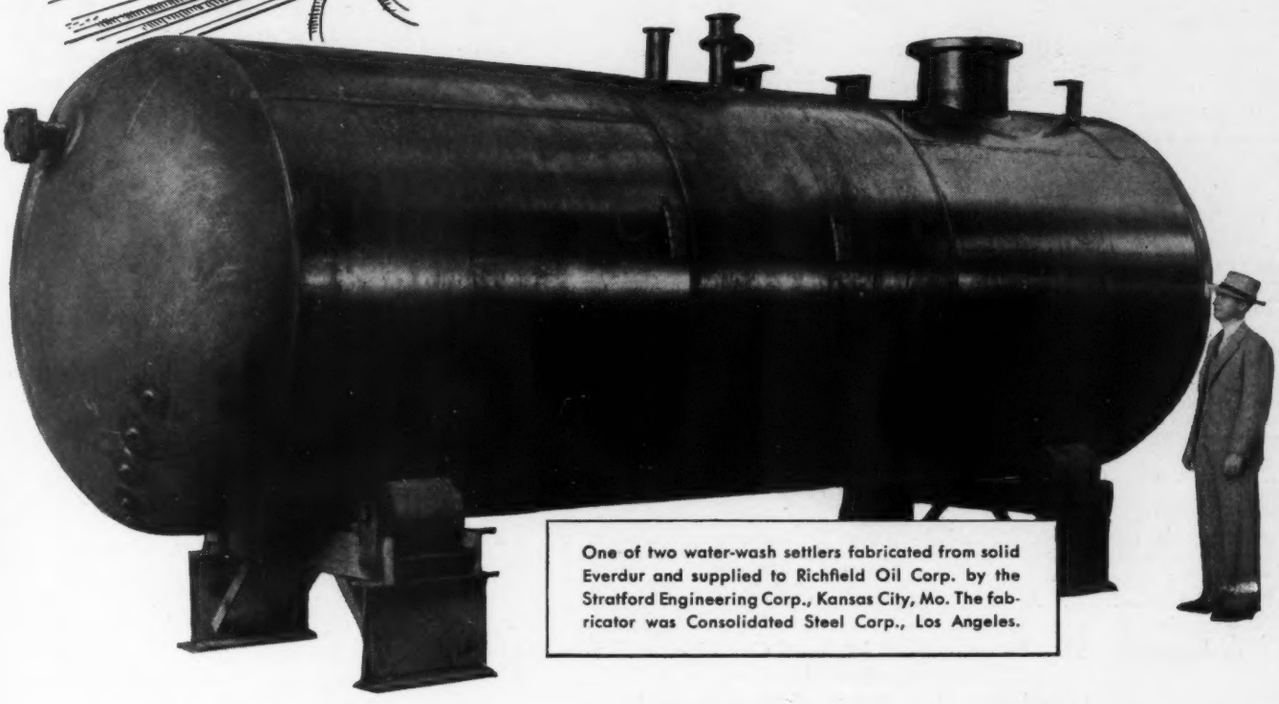
Regardless of the reasons for the large production of gasoline during the past winter, the industry seems, in a sense, to have borrowed from the amount that under other circumstances would have to be produced during the coming summer and while we are entering the season of the year when increased demand can normally be expected, it is a fact that a large portion of the gasoline which will be required to supply this seasonal increase in the level of consumption, has already been produced, and is included in the large amount of motor fuel presently in storage.

The liquidation of finished and unfinished gasoline during a summer season of normal conditions of stocks with demand at about current levels would be about 18,000,000 barrels. In 1936 the actual liquidation amounted to only 16,700,000 barrels, and in 1937 and 1939 it was even less. During 1938, however, these withdrawals amounted to more than 23,000,000 barrels, the largest amount yet recorded during a summer season.

I believe that 64,000,000 barrels represents minimum working levels of finished and unfinished gasoline inventories on September 30th next. I know that some will think this too low. On the other hand, there are some who will think it high. To me it represents a level below which these stocks cannot go if the industry is to operate economically and conveniently and to load cargoes and other shipments without undue delay. It is a sort of ideal situation, however, one in which each refiner and supplier has not more than his minimum requirements, a condition



Richfield chooses EVERDUR for water-wash settlers!



One of two water-wash settlers fabricated from solid Everdur and supplied to Richfield Oil Corp. by the Stratford Engineering Corp., Kansas City, Mo. The fabricator was Consolidated Steel Corp., Los Angeles.

Strong copper-silicon alloy provides high corrosion resistance at low cost

IN THE PROCESS of settling out acid water from water-washed cracked distillate, settling tanks must withstand the corrosive effects of a dilute sulphuric acid while operating under widely varying system pressures.

Because Everdur* has a proven performance record in such service the Richfield Oil Corporation recently installed two settlers of this highly corrosion-resistant, copper-silicon alloy in its new refinery.

Like many others in the field, this refiner has found Everdur to be an ideal solution to many problems encountered in process equipment. For, in addition to being resistant to a wide variety of corrosive agents, Everdur has approximately the tensile strength of mild steel, is tough and rust-proof and can be fabricated by all commercial methods.

Interesting engineering data is available on this high strength copper-silicon alloy. A note on your letterhead will bring the complete story. 3967

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Appendix IV—Stocks of Kerosene
(Barrels of 42 Gallons)

DISTRICT	January 31, 1939 U.S.B. of M.	March 31, 1939 U.S.B. of M.	Sept. 30, 1939 U.S.B. of M.	January 31, 1940 U.S.B. of M.
East Coast	999,000	841,000	2,248,000	842,000
Louisiana Gulf	483,000	493,000	702,000	233,000
Texas Gulf	2,116,000	1,645,000	3,267,000	1,300,000
	3,598,000	2,979,000	6,217,000	2,375,000
Indiana, Illinois, Kentucky	685,000	574,000	1,090,000	648,000
Oklahoma, Kansas, Missouri	736,000	533,000	699,000	408,000
Inland Texas	175,000	174,000	247,000	88,000
North Louisiana and Arkansas	203,000	90,000	184,000	102,000
	1,799,000	1,371,000	2,220,000	1,246,000
Appalachian	172,000	177,000	319,000	201,000
Rocky Mountain	101,000	108,000	119,000	108,000
EAST OF CALIFORNIA	5,670,000	4,635,000	8,875,000	3,930,000
California	1,041,000	970,000	1,077,000	988,000
United States	6,711,000	5,605,000	9,952,000	4,918,000

Appendix V—Stocks of Lubricants
(Barrels of 42 Gallons)

DISTRICT	January 31, 1939 U.S.B. of M.	March 31, 1939 U.S.B. of M.	Sept. 30, 1939 U.S.B. of M.	January 31, 1940 U.S.B. of M.
East Coast	2,294,000	2,349,000	2,022,000	2,429,000
Louisiana Gulf	198,000	168,000	125,000	317,000
Texas Gulf	1,760,000	1,801,000	1,655,000	1,514,000
	4,252,000	4,318,000	3,802,000	4,260,000
Indiana, Illinois, Kentucky	594,000	655,000	597,000	544,000
Oklahoma, Kansas, Missouri	590,000	616,000	436,000	558,000
Inland Texas	55,000	47,000	30,000	18,000
North Louisiana and Arkansas	51,000	44,000	42,000	59,000
	1,290,000	1,362,000	1,105,000	1,179,000
Appalachian	903,000	812,000	599,000	622,000
Rocky Mountain	98,000	101,000	94,000	86,000
EAST OF CALIFORNIA	6,543,000	6,593,000	5,600,000	6,147,000
California	1,219,000	1,207,000	1,104,000	1,181,000
United States	7,762,000	7,800,000	6,704,000	7,328,000

Appendix VI—Percentage Yields of Gasoline and Gas Oil and Distillate Fuels
(Based upon U. S. Bureau of Mines figures)

	EAST COAST		TEXAS GULF COAST		LOUISIANA GULF COAST		INDIANA, ILLINOIS KENTUCKY	
	Gasoline	G. O. & Dist.	Gasoline	G. O. & Dist.	Gasoline	G. O. & Dist.	Gasoline	G. O. & Dist.
1937								
January	37.9	17.5	39.8	15.6	32.3	19.3	53.6	11.5
February	42.6	17.0	43.2	14.1	35.3	16.6	54.1	11.4
March	41.1	14.9	41.9	12.3	32.7	16.9	56.5	10.0
April	39.1	13.1	45.6	12.3	37.6	20.1	55.0	9.9
May	39.7	12.0	42.6	12.3	33.6	17.5	55.3	9.6
June	42.4	12.3	41.4	13.1	34.9	11.4	56.8	9.9
July	39.7	14.1	41.7	14.4	34.6	10.6	54.4	9.6
August	37.6	13.7	42.2	14.1	32.0	15.0	57.0	10.1
September	40.3	15.0	41.4	14.3	36.8	13.7	56.4	10.4
October	41.3	17.5	43.3	14.6	34.1	11.5	56.7	10.2
November	40.5	16.0	42.2	16.1	33.9	15.5	55.1	9.2
December	40.1	19.1	42.0	14.3	33.9	17.0	56.0	12.8
1938								
January	40.3	19.4	44.1	15.5	35.1	16.7	53.8	12.3
February	36.0	16.6	42.1	16.3	36.3	19.3	53.4	11.2
March	38.0	14.4	42.3	14.1	30.7	16.0	55.4	10.4
April	41.0	13.0	41.9	14.2	32.8	13.0	56.5	10.2
May	41.4	13.6	43.0	15.1	30.1	16.7	58.1	9.0
June	41.5	12.5	41.1	14.8	34.1	13.3	57.4	8.9
July	40.7	14.5	43.6	17.4	37.6	12.7	56.4	9.1
August	41.0	14.9	44.5	15.3	39.3	11.2	56.4	10.8
September	41.6	16.5	44.8	15.6	41.3	17.1	56.0	11.7
October	38.2	17.7	45.4	16.4	37.8	15.9	54.6	11.4
November	40.8	16.6	43.8	14.5	41.8	19.1	56.1	11.4
December	40.2	19.6	43.7	16.0	34.8	19.4	55.4	11.2
1939								
January	40.2	19.1	44.1	16.7	34.1	15.8	55.2	11.2
February	39.4	20.8	42.5	17.1	37.0	17.7	54.7	10.8
March	38.9	16.2	43.4	17.1	36.5	17.4	53.7	9.0
April	39.6	15.5	44.2	15.8	39.2	15.9	54.5	9.7
May	38.5	13.4	44.3	15.0	40.8	14.6	52.9	7.8
June	37.9	13.1	44.6	18.3	35.6	19.4	56.1	8.7
July	40.2	13.1	43.2	15.8	36.4	12.9	54.7	9.0
August	40.8	13.1	44.4	15.8	38.3	16.5	56.2	10.6
September	39.9	16.4	43.9	14.7	39.1	14.1	56.5	9.4
October	41.2	16.5	45.3	16.6	34.2	15.0	55.0	11.1
November	40.9	15.7	45.6	16.1	37.3	15.2	54.5	10.8
December	39.4	19.2	43.9	16.5	38.1	16.5	53.1	10.4
1940								
January	38.8	21.2	39.1	19.2	32.5	14.1	53.3	12.6

which probably would never exist.

If actual inventories on September 30th next should represent a level close to economic requirements, a withdrawal considerably larger than any heretofore experienced will have been recorded.

It appears from studies of new car registrations and sales of automotive vehicles that the average number in use during the coming summer will show an increase of about 4½ percent above the number in use during the summer of 1939. It is also felt that the average unit will consume somewhat more gasoline during this season than was consumed by the average unit a year ago. While business activity, according to the Federal Reserve Board Index of Industrial Production, has been on the decline during the past four months, and does not yet show any real tendency towards a reversal of that trend, it is felt, nevertheless, that the rate during this summer will be at a higher level than last. Also that the unsettled conditions in Europe may reflect themselves in some increased travel here.

It was noted earlier that the industry must have approximately 64,000,000 barrels on September 30th next in order economically and conveniently to carry on its business. It is my further opinion that should actual inventories be close to that level at the end of this summer, with crude oil inventories no higher than at present, it will be after the industry has produced very little more than 3,500,000 barrels daily during the six-months period. If actual inventories on September 30th next are approximately equivalent to those of September 30, 1939, or about 70,000,000 barrels, crude oil production will then have approximated 3,650,000 barrels daily. Thus is indicated the range of production between minimum economic requirements of finished and unfinished gasoline on September 30th next and an amount approximately equivalent to the storage level of the year before.

Conclusion

In conclusion, I should like to leave the following summary of comments with you:

That domestic demand for motor fuel during 1940 probably will not be more than 5 to 6 percent above 1939. Export demand will be considerably lower than last year, and it is interesting to note, in this connection, that for every 6,000,000 barrels approximately that gaso-

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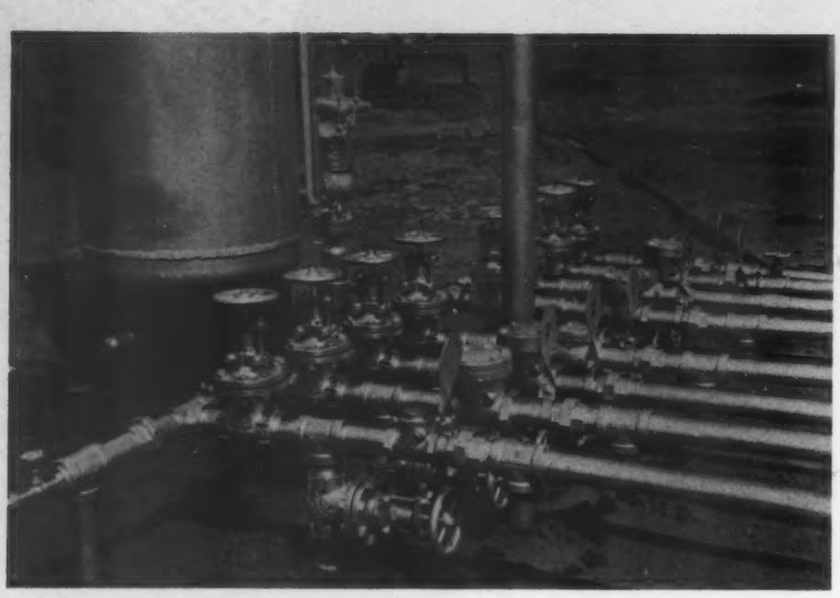

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Illustration shows a portion of the 700-lb. hydraulic-pressure Fairbanks Semi-Steel Gate Valves (Fig. 0351) installed at a Texas natural gasoline plant. This is but one of hundreds of oil and gas plants which have installed Fairbanks Valves during the past half century.

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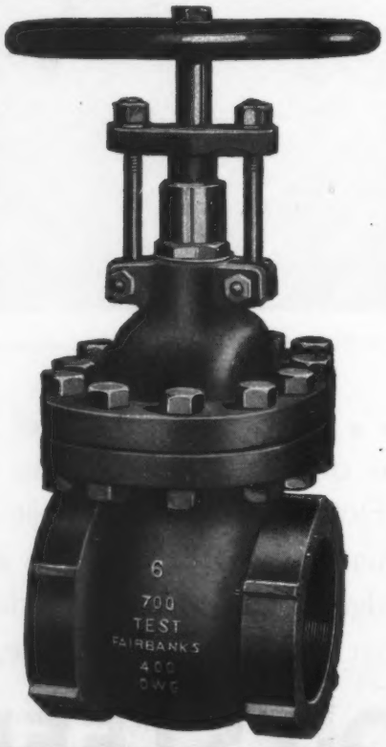

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line exports decline, when compared with a year ago, the domestic percentage increase figure is reduced 1 percent. In other words, even though the increase in domestic demand currently appears to be 5 or 6 percent, the expected low level of export shipments will reduce the increase in total demand to about 3 percent.

That motor fuel stocks are at their all-time peak and considerably above normal requirements. This is a clear indication that the industry has borrowed production of gasoline from that which normally would have been produced during the summer season.

That two of the contributing reasons for the currently large motor fuel inventories are the facts that the industry entered the 1939-1940 winter season with inventories of that product already high, but with insufficient light fuel oil in reserve.

That, if an improved set of conditions is to prevail at the end of the 1940-1941 winter, lower motor fuel stocks are indicated at the end of the coming summer, when compared with last year, and higher light fuel oil inventories.

That increased yields of light fuels are not only necessary but possible and entirely within the limits of flexibility of present facilities.

That it is not immediately apparent that the shifting of gasoline and light fuel oil yields within the necessary limits will affect octane requirements.

That this may not be the situation with respect to all refiners, but it would appear that in those districts in which this is an important problem reforming equipment and the other facilities necessary are generally available.

That because of this situation refiners' crude oil requirements during the coming summer will be based on normal gasoline yields, thus permitting the necessary variations of shift from gasoline to light fuel oil within the limits of flexibility of each refiner, thereby not twice allowing for the production of either gasoline or light fuels.

That in those districts where the gasoline-light fuel oil problem is not present, normal yields will prevail in any event.

That if finished and unfinished gasoline stocks as of September 30th next are higher than in 1939, it will be a direct reflection of a continuation of current high levels of crude oil production.

Presaturation Process

THE Fluor Corporation, Los Angeles, announces a new process for the natural gasoline industry, to be known as "Pre-saturation." Company officials consider this process to be an important contribution to the natural gasoline industry. A brief explanation of the process as released by the company is as follows.

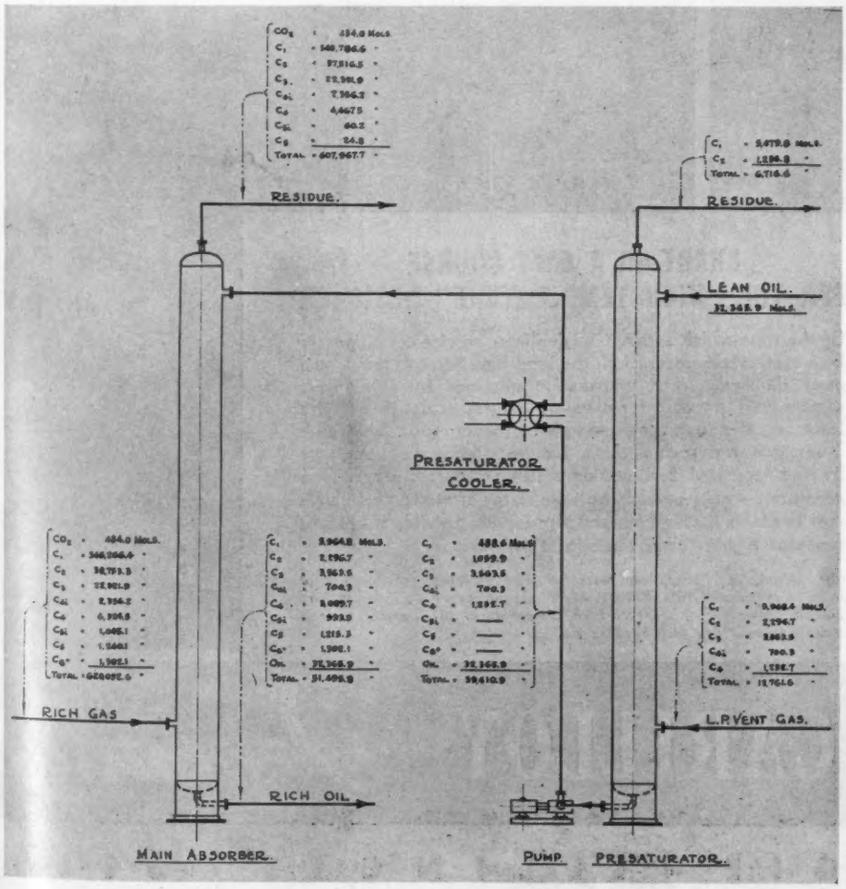
In many absorption plants it is desirable to return to the residue gas as much of the plant vent gases as possible. For this purpose it has been customary to install compressors to boost these gases up to residue gas pressure. Especially is this true in pipe-line gasoline plants.

Furthermore, where incoming gas to a plant contains a large amount of propane and considerable excess butane, over and above that permissible in the finished gasoline, an excessively high temperature rise is encountered in the main absorbers, due to the absorption of propane and butane. If the temperature rise, due to the absorption of these constituents, could be eliminated, it would be possible, in a number of plants, to reduce the oil rate. Therefore, to accomplish the dual purpose of returning vent gas vapors to the residue gas, and of reducing the excessive temperature rise in the absorbers, the Pre-saturator system was developed.

Contacted With Oil

In using this system all the normal vent gases in the plant are contacted with all the oil passed over the main absorbers, at as high a pressure as it is practical to handle these vapors without recompression. In the average plant this pressure is sufficiently high to absorb substantially all the propane in these vent gases, as well as all the butane. Naturally some of the methane and ethane will also be absorbed.

During the absorption process, the temperature of the oil passing through the Pre-saturator will be raised and oil from this device is then cooled and pumped over the main absorbers. Assuming that all the propane has been absorbed by the oil in the Pre-saturator, it is apparent that this pre-saturated oil passing through the main absorber, will not pick up additional propane from the incoming gas, for the pre-saturated oil entering the main absorber contains as much propane as is required to saturate it under main absorber conditions.



Typical Presaturator Flow.

Example from Use

Therefore, the total incoming propane to the main absorber, instead of being absorbed when contacted by ordinary instead of pre-saturated absorption oil, passes out with the absorber residue gas. Any butane absorbed in the pre-saturating step will counteract butane absorption in the main absorber, so that the net butane absorption in the main absorber consists only of the butane sold as a finished product.

As an example of the value of this system in a plant on stream, the following data obtained in operation of a high-pressure absorption plant, is given:

The high pressure absorption plant was operating at pressure in excess of 700 pounds gauge, and handling over 200,000,000 cubic feet per day. The vent gases from this plant amounted to approximately 4,500,000 cubic feet per day. Out of this vent gas, approximately 600,000 cubic feet was used for boiler fuel, leaving a balance of 3,900,000 cubic feet per day, to be either recompressed into the high-pressure gas line, or blown to the air. Compression totaling 400 horsepower was being used at the plant to recompress all but 150,000 cubic feet into the residue line. This remaining gas was being blown to the air. After putting the Pre-saturator into service, the recompressors were shut down, no gas was blown to the air and betwen 20,000 and 30,000 cubic feet of gas from the main line was required to make up sufficient volume for the boiler plant.

The benefits claimed for presaturation are:

1. Valuable vent vapors, which in a majority of instances are either blown to the air, used as fuel, or recompressed at a cost, are made available for sale as a higher Btu content residue gas.

2. Plant extraction, by virtue of a substantial reduction in main absorber oil temperature, will usually show a substantial increase in yield.

3. Initial costs for compressor horsepower in a new plant will be reduced; in plants on stream a considerable reduction of operating and maintenance of such equipment is effected.

TO HELP YOU

CHARTING A SAFE COURSE FOR THE "HIGH TEMPERATURE" DESIGNER

Of the tests which attempt to duplicate service conditions of high temperature operation, the long-time "creep" test is the most significant. The information obtained from this test can be used not only for avoiding failures in design but has led to the development of new and stronger steels. The value of research work such as this is demonstrated in a striking way by the increased fuel economy being reported by central generating stations which, because of the stronger steel alloys now available for high temperature service, are able to operate safely at higher temperatures and pressures.

(A) *Measuring "creep" in tests for slow yielding under stress at high temperature.* (B) *Taking exact measurements of strength and elastic properties of steel at high temperature.* (C) *Testing welded sample in root and face bending jig.*

A

B

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The Look Box

Natural Gasoline Men Plan 3-Day Session

For its nineteenth annual convention in Tulsa, May 15, 16 and 17, the Natural Gasoline Association of America will have three days of technical sessions, entertainment in the form of two luncheons and a dance, and the delegates will be guests of the management of the International Petroleum Exposition the afternoon of May 17. The exposition will open formally the next day.

Entertainment will be provided by the Natural Gasoline Supply Men's Association, an organization which was formed for the one purpose of working with this one association. Luncheons will be served May 16 and 17. An informal dance at the Tulsa Club will be held the evening of May 16.

All sessions will be held in the Tulsa Hotel. The program May 15 will begin with the address of George P. Bunn, Phillips Petroleum Company, association president.

The complete program follows:

"New Test Methods and Specifications for Liquefied Petroleum Gases," C. R. Williams, Continental Oil Company, chairman of the technical committee.

"The N. G. A. Standard Form of Casinghead-Gas Contract," James E. Allison, Hanlon-Buchanan, Inc., chairman of the gas contract committee.

The afternoon program will start with an address by H. H. Anderson, Shell Oil Company, St. Louis. Two technical papers will complete the program for this day:

"The Economics of Liquefied Petroleum Gases," James W. Vaiden, Skelly Oil Company;

"The Value of Standardization to the Pacific Coast Natural Gasoline Industry," W. W. Robinson, Jr., The Texas Company of California.

The program for the second day will be confined to technical subjects:

"Revised Charcoal Method for Testing Gas," H. L. Oder, Cities Service Oil Company, chairman of the gas-testing committee;

"Neo-Hexane, the Fuel of Tomorrow," R. C. Alden, Phillips Petroleum Company;

"The Position of Natural Gasoline in Conservation," H. B. Barnard, consulting engineer, Tulsa.

Presentation of the Hanlon award for outstanding service to the natural gasoline industry;

"Developments in the Gas Recycling Plants," E. E. DeBach, Corpus Christi Corporation;

"The Measurement of Gas Flow Under High Pressure," G. G. Brown, University of Michigan.

Most of May 17 will be devoted to consideration of "Operating Kinks," the presentation of original ideas submitted by field, plant and laboratory workers. This will start the program in the morning and will be followed by, "Elimination of Hydrate Troubles," E. G. Hammerschmidt, Texhoma Natural Gas Company.

In the afternoon the consideration of "Operating Kinks" will be continued and awards made.

The Natural Gasoline Supply Men's Association will hold its annual meeting the morning of May 15.

GEORGE P. BUNN

Annual Meeting June 20 and 21

The annual meeting of the Pennsylvania Grade Crude Oil Association will be held June 20 and 21 in the Hotel Emery, Bradford, Pennsylvania. This will be the first meeting in Bradford since 1932.

CONVENTIONS

MAY	
13–15	**American Institute of Chemical Engineers, Statler Hotel, Buffalo.**
15–17	**Natural Gasoline Association of America, Hotel Tulsa, Tulsa.**
18–25	**International Petroleum Exposition, Tulsa.**
27–31	**American Petroleum Institute, Mid-Year Meeting, Blackstone and Texas Hotels, Fort Worth.**
JUNE	
9–14	**Society of Automotive Engineers, the Greenbrier, White Sulphur Springs, New York.**
17–20	**American Society of Mechanical Engineers, Milwaukee.**
20	**Pennsylvania Grade Crude Oil Association, Emery Hotel, Bradford.**
24–28	**American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City.**

A.P.I. Technical Refining Program

Sessions of the Refining Division of the American Petroleum Institute will be held May 29 and 30 at the mid-year meeting in Fort Worth, May 27 to May 30. The Crystal ball room of the Texas Hotel will be used for these meetings.

Both the Blackstone and the Texas Hotels will be meeting places for the tenth mid-year meeting, which will start with committee sessions May 27 and wind up with a golf tournament at the Colonial Golf Club May 31.

The general session May 29 will be a luncheon at which Bruce Barton, New York congressman and president of Batten, Barton, Durstine and Osborn, Inc. (advertising), will give an address.

The board of directors will have one session the morning of May 29.

A barbecue will be given the evening of May 29 at the farm of Amon G. Carter, Fort Worth publisher and a director of the institute.

The program of the technical sessions of the Division of Refining is:

Refinery Problems
May 29, 9:30 a. m.

"Selection of the Most Economical Pipe and Valve Rate of Flow in Piping Systems," S. P. Johnson and F. L. Maker, Standard Oil Company of California.

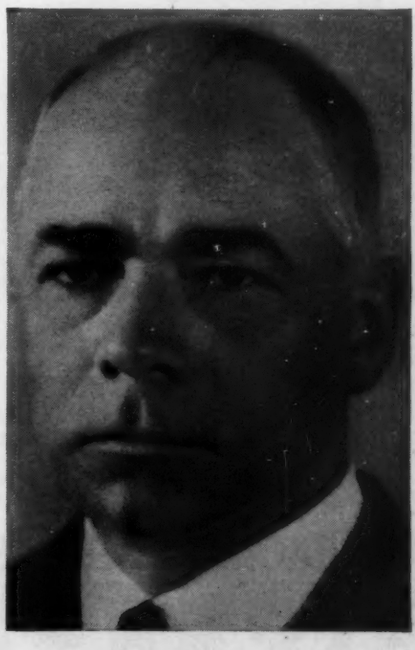
"Application of Superheated Steam in Combination Unit Prime Movers," A. E. Harnsberger, The Pure Oil Company.

"Some Factors Influencing the Efficiency of Filter Clays," L. M. Henderson, C. M. Ridgway and W. B. Ross, The Pure Oil Company.

"Practical Removal of Sulfuric Acid by Bubble-Phase Absorption," D. W. Bransky and F. F. Diwoky, Standard Oil Company (Indiana).

Refinery Corrosion
May 29, 2:30 p. m.

"Corrosion of Copper and Copper-Base Tubing in Oil Refinery Heat-Transfer Equipment," R. W. Wilkins,



J. HOWARD PEW

E. S. Bunn and W. Lynes, Revere Copper and Brass, Inc.

"Copper Alloys and Their Application in Petroleum Refining," James T. Kemp, American Brass Company.

"Results of Corrosion Tests in Oil Refineries," N. W. Mitchell, Chase Brass & Copper Company.

"The Method of Testing Alloy Tubes and the Use of Inhibitors," F. M. Barry, Scovill Manufacturing Company.

"Testing of Non-Ferrous Alloys for Condenser Tube Service Under Conditions Simulating Actual Industrial Service," R. W. Moore and S. Kleinheksel, Socony-Vacuum Oil Company.

"Cathodic Protection of Condensers and Coolers Utilizing Brackish Bay Water," N. F. Myers, W. A. S. Wright and J. H. Brooks, Union Oil Company of California.

"A Discussion of Some Controlling Factors in Corrosion of Heat Exchangers and Condensers," R. L. Duff, Standard Oil Development Company.

Fuels
May 30, 9:30 a. m.

"Significance of the Doctor Test for Gasoline," John Happel and S. P. Cauley, Socony-Vacuum Oil Company.

"Performance Testing of Motor Fuels, Development of Conversion Formulas for Values by Various Methods," Herschel G. Smith, Gulf Oil Corporation.

"Knocking Octanes," H. W. Field and C. H. Van Hartesveldt, The Atlantic Refining Company.

Bureau Sees Demand Loss Due to Export Curtailment

Placing the probable crude production necessary to meet demand in May at 3,601,000 barrels a day, the Bureau of Mines on April 18 warned the industry not to look for any marked improvement in the market demand for domestic petroleum during the next three months.

A combination of influences, the bureau said, will act to keep demand at about the level anticipated for May, the forecast for which contemplates an increase in daily output of 51,000 barrels over the current month and 35,200 barrels over actual demand in May, 1939. Important among these factors will be the heavily reduced export trade which, the bureau said, "reflects the difficulties of obtaining tankers, the risk of over-seas shipments, as well as curtailment of consumption through rationing and the diversion of purchases to other sources of world supply." Motor fuel exports, it is estimated, will be fully one third less than during May of last year.

"According to available data, the daily average domestic demand for motor fuel showed an increase of about 6.5 percent for the first quarter of 1940 but the total demand increased only 3 percent," it was pointed out in a discussion of the current situation. "Market trends for the second quarter indicate a probable increase of about 7.5 percent in the domestic demand for motor fuel but an increase in total demand of about only 4 percent, due to the sharp reduction in exports from last year.

"The estimated total of finished and unfinished gasoline stocks on March 31, 1940, was approximately 102,000,000 barrels, or 15,000,000 greater than a year ago. If this unusual seasonal increase is liquidated, it will supply the greater part of the expected increase in gasoline demand for both the second and third quarters, and the required refinery production of gasoline would approximate that of last year during these periods. As the demand for all oils indicates a moderate increase in crude runs, gasoline yields will be substantially below last year, if a proper balance between products is attained.

Higher Distillate Yields

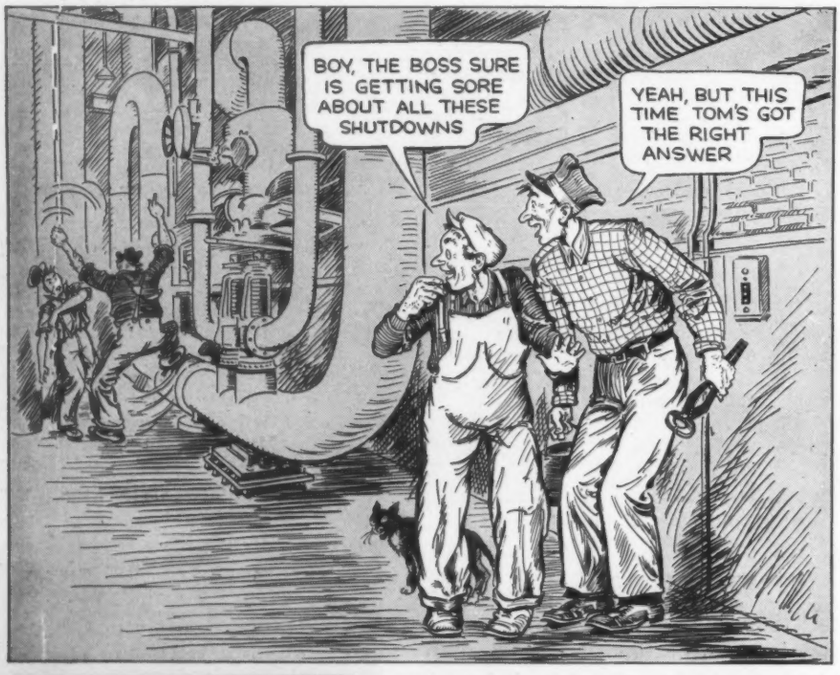
"A higher seasonal yield of distillate fuel oils is indicated to build up depleted stocks and provide for increased domestic demand," the bureau continued. "The domestic demand for heavy fuel oils, reflecting the drop in the index of industrial operations, currently is not greatly above last year and, from present trends, part of any additional requirements may be met by imports. A sharp decline in exports is an added factor in reducing the increase in the total demand for fuel oils.

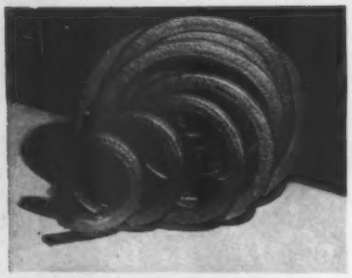
"If the decline in exports of crude oil continues, it may offset the expected increase in refinery crude required and result in only a minor gain in the total market demand for domestic crude petroleum in the summer months as compared with last year.

"Due to the combined effect of these various factors, the Bureau of Mines does not anticipate that the forecast of market demand for domestic crude will be increased greatly either in June or July over May."

The bureau found that daily average

KEEPING 'EM ROLLING **By WESTCOTT**





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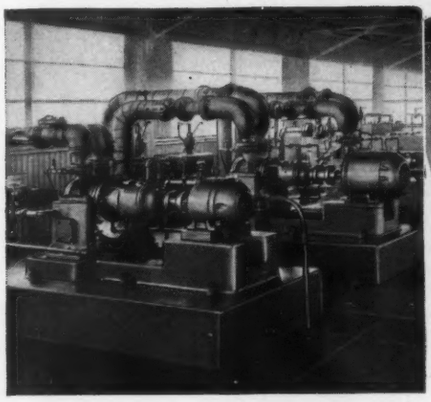
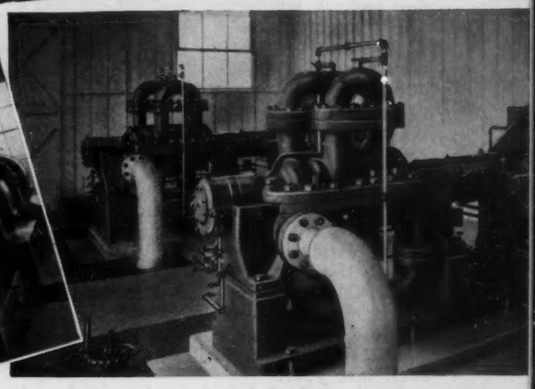
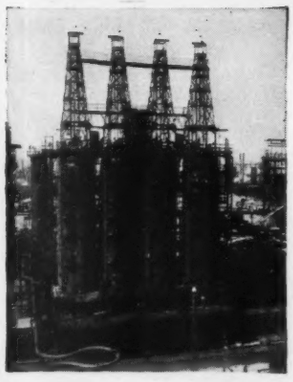




Two Worthington centrifugal pipe line pumps driven, through fire wall, by Worthington 280-hp. Diesel engine



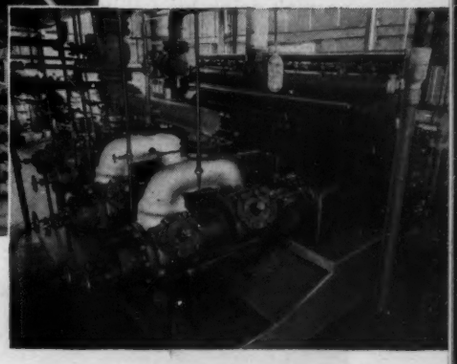
Above left—Two Worthington Type H centrifugal pumps handling hot oil

Above right—Three Worthington duplex pumps, electric motor driven, pumping cold oil at 1500 lb. per sq. in. discharge pressure

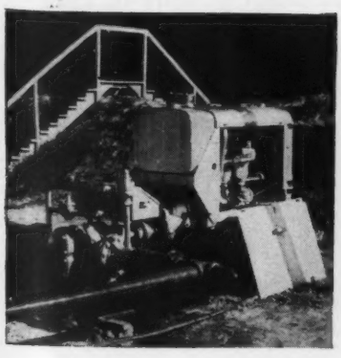
Left—Complete hydraulic decoking and coke transportation systems for economical removal and transportation of coke from coke chambers in oil refineries

Worthington-Carbondale chilling machines, for ammonia direct-expansion operation in a solvent dewaxing plant

Below—Worthington LCE angle gas engine compressor, with ammonia compressor cylinders, on refrigeration service in a lubricating oil dewaxing plant



Below left—Worthington rotary pump, gas-gasoline engine driven, in gathering service in the oil fields



Worthington HiVoL direct-acting pumps handling gasoline

Worthington centrifugal pumps in line, driven by Moore steam turbines, in oil refinery service

Worthington power pump driven by gasoline engine with Worthington Multi-V-Drive...in oil gathering service

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WORTHINGTON

crude production during the 4 weeks March 9 to April 6 was 3,837,000 barrels and runs to stills during the same period 3,525,000 barrels. Meanwhile, domestic crude stocks increased an average of 194,000 barrels daily, indicating a daily average demand of 3,643,000 barrels, compared with the bureau's estimate of 3,511,000 barrels. The difference between estimated and actual demand, it was explained, is attributable to larger runs, which ran about 175,000 barrels daily more than the bureau's estimate, which resulted in an addition of approximately 3,300,000 barrels to the top-heavy gasoline inventories during March. The increase of about 5,400,000 barrels in domestic crude stocks, in addition to the high runs, it was pointed out, "indicates that crude oil was being produced far in excess of current needs."

Domestic demand for motor fuel during the coming months is estimated at 52,400,000 barrels, an increase of 6 percent over the actual May, 1939, demand, but exports are figured at only 2,800,000 barrels, 1,590,000 barrels less than last year.

Stocks of finished and unfinished gasoline on February 29 amounted to 99,295,000 barrels and statistics of the American Petroleum Institute indicate that they increased more than 3,000,000 barrels during March, which would place them at least at 102,000,000 barrels as of March 31, the report said. "The reduction of these stocks to a normal point by fall will require the maintenance of a modest level of refinery operation during this spring and summer with particular attention being given to the accumulation of heating oil stocks for the fall demand," the bureau warned. It estimated that finished stocks of gasoline will be reduced 4,200,000 barrels during May.

Benzol and direct sales of natural gasoline are estimated at 1,000,000 barrels, making a refinery production of 50,000,000 barrels, which the bureau has allocated among the several districts, as follows:

East Coast, 6,680,000 barrels; Appalachian, 2,050,000 barrels; Indiana-Illinois, 9,880,000 barrels; Oklahoma, 2,860,000 barrels; Kansas-Missouri, 2,610,000 barrels; Inland Texas, 3,650,000 barrels; Texas Gulf Coast, 12,370,000 barrels; Louisiana Gulf Coast, 1,540,000 barrels; Inland Louisiana-Arkansas, 890,000 barrels; Rocky Mountain, 1,310,000 barrels; California, 6,160,000 barrels.

Natural gasoline to be blended at refineries is figured at 5.5 percent to the total refinery gasoline production, or 2,760,000 barrels, and the yield of straight-run and cracked gasoline is estimated at 43.9 percent. Application of this yield to the production of 47,240,000 barrels of gasoline gives crude runs of 107,630,000 barrels, or 3,471,900 barrels a day. Foreign crude runs are estimated as 3,000,000 barrels.

As in the case of gasoline, crude oil exports for the coming month are placed at a much lower figure than actual shipments last year, 5,000,000 barrels as compared with 8,643,000 barrels. Crude oil to be used as fuel and losses is estimated as 2,000,000 barrels, giving a total demand for domestic crude oil in May of 111,630,000 barrels or 3,601,000 barrels daily.

Facilities Enlarged For Exposition

Additional facilities for the International Petroleum Exposition, Tulsa, May 18 to 25, have brought the investment to $750,000. The exposition is now the largest industrial exposition in the world. For the coming show it was necessary to enlarge the Hall of Science and provide an international building. In addition 11 manufacturing companies erected permanent buildings on the grounds.

Improved methods of refining will be seen in both the Hall of Science and in exhibits of manufacturers. An exhibit of special interest within refining will be the development of return bends for tube stills.

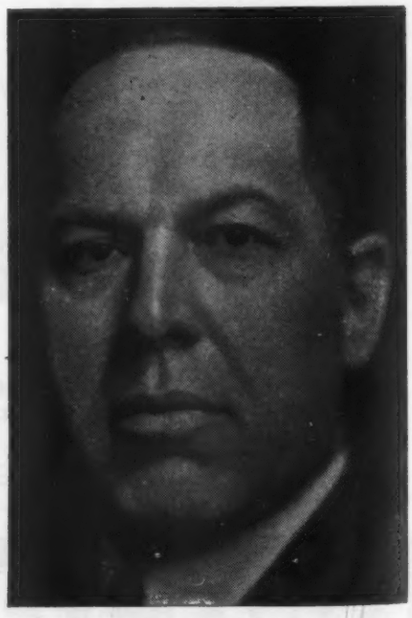
The Natural Gasoline Association of America is cooperating with the Society of Automotive Engineers in a display of modern knock test engines, another exhibit of the Hall of Science. One engine will be for aviation-grade-motor-fuel testing, another will be for Diesel fuels. A third engine on display will be a 2000 horsepower radial aviation motor with cylinders in double banks. The model will have cylinders cut away and the interior will be illuminated so the parts can be seen while they are operated slowly by electricity.

In connection with aviation there will be a Link trainer, which is used in training pilots for blind flying.

Among the precision instruments to be displayed will be the new 50-place refractometer for high precision in analyzing oils on the basis of dispersion readings. Microscopes, new type drying ovens, cutting torches, gas detectors, the fluoroscope, and magnetos will be in other displays.

The addition to space in the Hall of Science will allow the showing of films, many of which will show refining and manufacturing processes.

Exhibits in the Hall of Science are under direction of the scientific and technical committee, of which Dr. Gustav Egloff, Universal Oil Products Company, Chicago, is chairman. Chair-



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THE two C-F Low-Pressure Regulators with Automatic Cut-Off here seen, are on a gas line of a Texas refinery owned by one of the great oil-producing companies. Like all C-F low-pressure Regulators, they afford protection in case of failure of gas supply. Their merits include sturdy construction, sure precision, and long life as well as easy installation and maintenance. See our exhibit at Tulsa. Write for new Catalog.

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Magnifying Adjustment Dials—Easier to read, adjust. Calibrated in absolute units.

Easy Convertibility—From direct to reverse action.

Universal Case—Made of die-cast aluminum, for face or flush mounting.

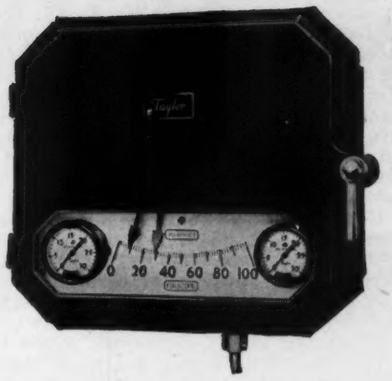
Electric Chart Clocks—Redesigned, with improved coils, oil-immersed gears, and slower-speed motors. Spring-driven clocks are an alternate. Explosion-proof electric clocks are also available.

Inbuilt Air Filters—Easy to clean, more efficient and accessible. They supplement large filter and drip well.

Quicker Chart-Changing—Separate pen lifter and hub nut eliminated.

Accessibility—Dials and knobs instantly accessible without removing chart and chart plate.

Greater Sturdiness—All vital parts of 18-8 stainless steel. Neoprene gaskets throughout.



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. . . has the same unit construction, control mechanism, design features, and performance characteristics as the Taylor Fulscope Recording Controller, but comes in single-duty form only.

The new Taylor Recorder

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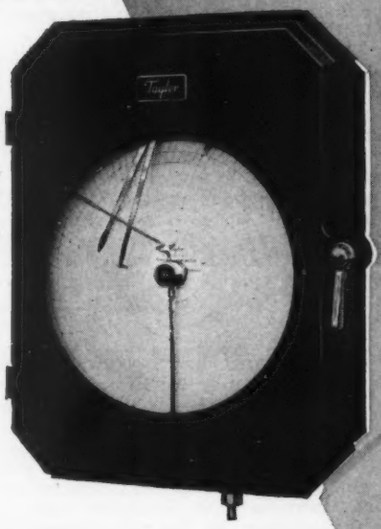
. . . It contains all the fine features of the new Fulscope which are not exclusively control. Like its twin, it's an outstanding performer with significant improvements that promise all-round better results.



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Easy Convertibility—All cases drilled and tapped so that various Fulscope Controller units may be added if desired. Your job of changing your instrument from a recorder into a controller is simple—no complicated fuss or bother.

Dust-proof, Moisture-proof Case—Neoprene door gaskets and improved door latch give a positive door seal. The sturdy, chromium-plated door handle has a bayonet action. Can be locked with a padlock, or cylinder type lock can be installed.

Rigid Chart Plate—This is of die-cast aluminum, permitting easier pencilled chart notations—it carries the chart clamp and pen lifter, too.

Quicker Chart-Changing—The chart-clamping mechanism combines the chart locking device and pen lifter in one unique design. You release the chart and lift the pen merely by pulling the chart knob outward—and replace the chart just as easily. It makes chart-changing a one-hand operation that takes only half as long.

Improved Actuating Units—The same strong, durable Taylor Bourdon spring has been made reversible, with a take-off lug and new sub-base. Accurate instrument calibration is now easier than ever.

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Electric Chart Clocks—They have been redesigned—now have improved coils, oil-immersed gears, and slower-speed motors. Spring-driven clocks are an alternate. Explosion-proof electric clocks are also available.

Simplified Tube System Replacements—The new replacements are calibrated and correctly located on the sub-base and changes in the field can be made easily and quickly.

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International Petroleum Exposition
Booths 32, 33, 34

▶ See the new Taylor Fulscope Controller and its twin, the new Taylor Recorder. Find out first hand how Pre-Act acts. Learn how you may have any of 5 forms of control in one Taylor Controller. Want to hear what's new? Talk with Taylor!

INSTRUMENTS . . . Indicating · Recording · Controlling

men of the sub-committees within this larger committee are: natural gas, Frank B. Long, Oklahoma Natural Gas Company; modern laboratory, W. A. Schleuter, Refinery Supply Company; natural gasoline, William F. Lowe, Natural Gasoline Association of America; refining, John C. Day, Western Petroleum Refiners Association; temperature instruments, E. H. Triphause, Taylor Instrument Companies; safety, Henry W. Boggess, Sinclair Prairie Oil Company; treating, Dr. C. W. Rippie, Solvay Sales Corporation; gas engines, D. K. Hutchcraft and George W. Probst, Clark Engineering Company.

The safety contest, an event at each exposition, as well as other phases of first-aid activity will be under supervision of the central safety committee. Chairmen of sub-committees in safety are: scientific exhibit, R. E. Vickery, Sun Oil Company; exhibitors contact, J. E. Dyer, Sun Oil Company; first aid, J. W. Atkins, The Texas Company; conference, E. D. Murphey, Mid-Continent Petroleum Corporation; contest, R. S. Huffman, Oklahoma Natural Gas Company; banquet, N. T. Markee, Phillips Petroleum Company; monument to safety, D. J. Wallace, Sinclair Prairie Oil Company; publicity, A. W. Letson, Jr., Mid-Continent Petroleum Corporation.

May 23 has been designated Safety Day on the exposition program. A conference on safety will start that morning, continue in the afternoon and be completed with a banquet and the awarding of prizes from the safety contest that evening.

Delegates from foreign oil-producing countries will be entertained by special events, one of which is a banquet May 21. Visitors from these countries will have opportunities to visit nearby oil fields and refining plants. The new international delegates building has been provided as a meeting place and will be headquarters for foreign representatives. Chapters of the Nomads club will be hosts at the new building.

Government Draws N. P. A. Criticism

Criticism of the effort to impose federal control on the petroleum industry and of the federal labor laws were parts of the program of the semi-annual meeting of the National Petroleum Association, Cleveland, April 18 and 19. Governor Carl E. Bailey of Arkansas decried the move toward federal regulation. N. H. Weber, association president, dealt with the labor laws in his address. Other parts of the program dealt with technical and semi-technical subjects.

Governor Bailey pointed out that waste in the industry is not as flagrant as adherents of the Cole bill insist and added:

"Even if oil and gas were being wasted by the choice of the people, I contend that no man and no one group of men have any right to proceed any further than to attempt to educate and persuade the people not to commit such waste. It would be better for the oil and gas resources of the nation to be wasted than for our form of government to be changed so as to give control of the people and their destinies into the hands of bureaucrats and quack statesmen."

Weber objected to provisions of the Wagoner act, saying:

"The employer has no standing in the National Labor Relations Act. He is given no liberty but is throttled with a mass of prohibitions.

"It seems to me that with the number of congressional objectors there will be changes in the act that will insure more fairness for industry and a healthy change in its administration. However that may be, we can be assured we will have a labor act."

Longer driving periods between changes of crankcase oil was the general subject of J. M. Koch, sales director of Quaker State Oil Refining Corporation. He discussed the trend as a serious one for both the refining industry and for the automobile owner. He said the lengthening of the drainage period had cost the refining industry $14,000,000 in two years and predicted a loss of $50,000,000 a year if the trend continues.

In discussing objectives of the lubrication committee of the American Petroleum Institute, R. A. Ludlow, director, pointed out that mileage between drains was 1,547 in 1936; 1,772 miles in 1938 with indications that it will reach 2,250 miles in 1942. Of the objectives of the committee he said:

"It is a plan to assure the car manufacturer that his customers will enjoy satisfactory use of the car he sells. We know it has at heart the interests of the motoring public and that lubrication service can and should play an important part in keeping the car owner satisfied with his investment."

J. B. McCauley of Chrysler Corpora-

You'll Like THIS Plastic Packing!

For every service where a plastic packing is desired—use Garlock *Plastallic*. These superior plastic packings are scientifically compounded to Garlock formulae. Only the purest asbestos fibre, soft metals, graphite and special lubricants enter into their construction.

Garlock *Plastallic* is easy to apply; in service it combines into one homogeneous mass. Garlock *Plastallic* Packing is supplied in coil, spiral, ring and loose or bulk form and in various styles for gasoline, oils, water, steam, air, acids and chemical solutions. Write for descriptive folder.

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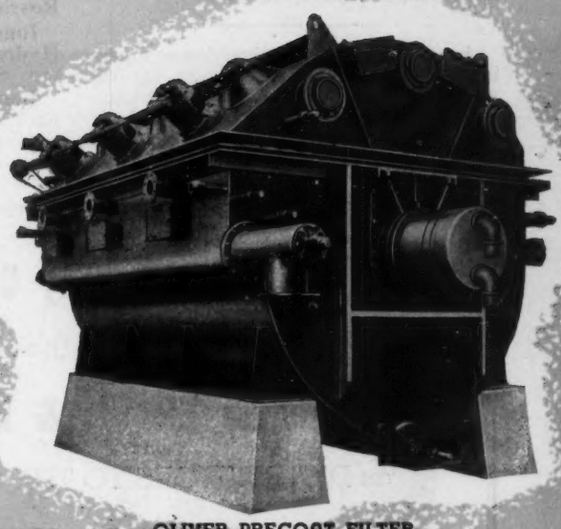
FILTERS *for Refineries*

. . . engineered and built to meet the various processing needs by the company that pioneered modern filtration and clarification in the continuous vacuum, continuous pressure, and the intermittent pressure fields. Experience dates back to 1907.



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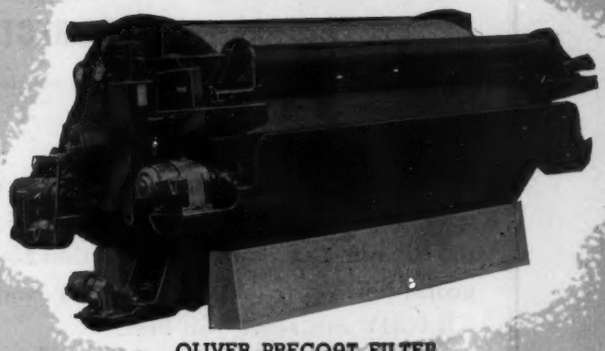

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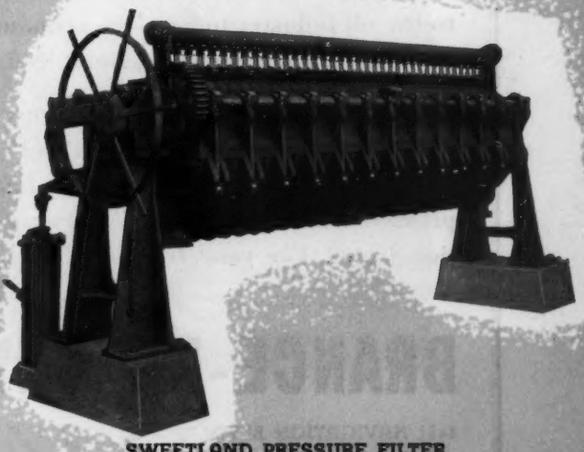

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Keep these facts in mind when confronted with a filtration or clarification problem. It will pay to bring your problem to the one company serving oil refineries that has made filtration its life work.

Oliver United is a group of filtration specialists of whom several have been studying refinery filtration problems for years and have developed special filters for them. Call on these men to help take care of the filtration steps in your plant.

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FACTORIES: HAZLETON, PA. AND OAKLAND, CALIF.

tion in, "The Octane Problem From the Automotive Viewpoint," said the only answer to the question of what octane requirement future cars will require lies in what normal regular gasoline will provide on this specification.

"The automotive engineer," he said, "would like to have an absolutely knock-free fuel. He is not likely to get it but if he had it he would keep on doing what he is doing now, that is, to exploit its properties to provide better and cheaper transportation."

Arnold Evans, who has been superintendent of the Galva, Kansas, natural gasoline plant for Warren Petroleum Corporation, has been transferred to the Monument, New Mexico, plant in similar capacity.

Research Conferences

A part of the program of the chemistry section of A. A. A. S., Gibson Island, Maryland, will be devoted to refining under the title, "Frontiers in Petroleum Chemistry," with Cary R. Wagner chairman. This program is:

June 17, "The Analysis of Petroleum as Exemplified by Project No. 6 at the Bureau of Standards," Frederick D. Rossini.

June 18, "The Production of Aromatic Hydrocarbons from Petroleum," Gustav Egloff.

June 19, "Alkylation," E. V. Murphee; "Isomerization," C. W. Montgomery.

June 20, "Oxidation of Lubricating Fractions," L. L. Davis.

June 21, "Investigation of the Combustion Characteristics of Pure Hydrocarbons," T. A. Boyd.

The conference on catalysis will have E. C. Williams as chairman with the following program:

June 24, "Modern Physical Methods in the Study of Catalysis," Otto Beeck.

June 24, "Theories of Polymerization and their Consequences," R. E. Burk.

June 26, "Surface Area Measurements in Studying Catalytic Reactions," P. H. Emmett.

June 27, "Fermentation," Kenneth Blanchard.

June 28, "The Definition of Absorption and Surface Characteristics of Catalysis," H. S. Taylor.

Hanneken Elected Director of Sohio

George W. Hanneken, vice president in charge of manufacturing of Standard Oil Company was elected a director at the annual meeting of stockholders in April. Also elevated to a directorship was Sidney A. Swensrud, vice president and in charge of business research and other departments.

These additions increased the directorate of the company to seven members. Others are W. T. Holliday, president; A. M. Maxwell, W. J. Semple, and A. A. Stambaught, vice presidents; and William A. McAfee.

Shawnee Dalton Goes With Socony-Vacuum

Shawnee Dalton, chemical engineer in the process of laboratory of General Petroleum Corporation, Vernon, California, has joined the staff of Socony-Vacuum Oil Company and will be in the engineering division of the general manufacturing committee.

Brance-Krachy Co., Inc.

is proud to announce their appointment by

Westinghouse Electric & Manufacturing Co.

as DISTRIBUTORS TO THE OIL INDUSTRY of

WESTINGHOUSE CATHODIC PROTECTION EQUIPMENT AND "RECTOX" RECTIFIERS

(Designed and built in their Houston Shop)

NOT just through our years of service to the oil industry generally; but specifically because of our pioneering in the development of Cathodic Protection for refineries—for underground pipe, for tank bottoms, for condenser tubes, BRANCE-KRACHY can serve you best.

Don't overlook this newest development, of vital interest to the oil industry today—the economy that can be effected by Cathodic Protection throughout refineries.

Be sure to get your free copy of the new, instructive "Trends in Cathodic Protection" (1940 Edition). Just off the press, this book contains all the latest developments on the problems of the installation and operation of Cathodic Protection Units. For your free copy, just write

BRANCE-KRACHY CO., INC.

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See the latest Cathodic Protection Units and Rectifiers in the Westinghouse Booth at the Tulsa Oil Show, May 18th through 25th

It is an anniversary year for Warren Petroleum Corporation, which was organized March 15, 1922. Within the 18 years the company has grown from a marketing organization for natural gasoline into one of the leading manufacturers and exporters of this product.

In the picture are W. K. Warren, seated, president; J. A. LaFortune, left, vice president; H. E. Felt, secretary. The company has headquarters in the National Bank of Tulsa building.

3 HOUDRY *Highlights*

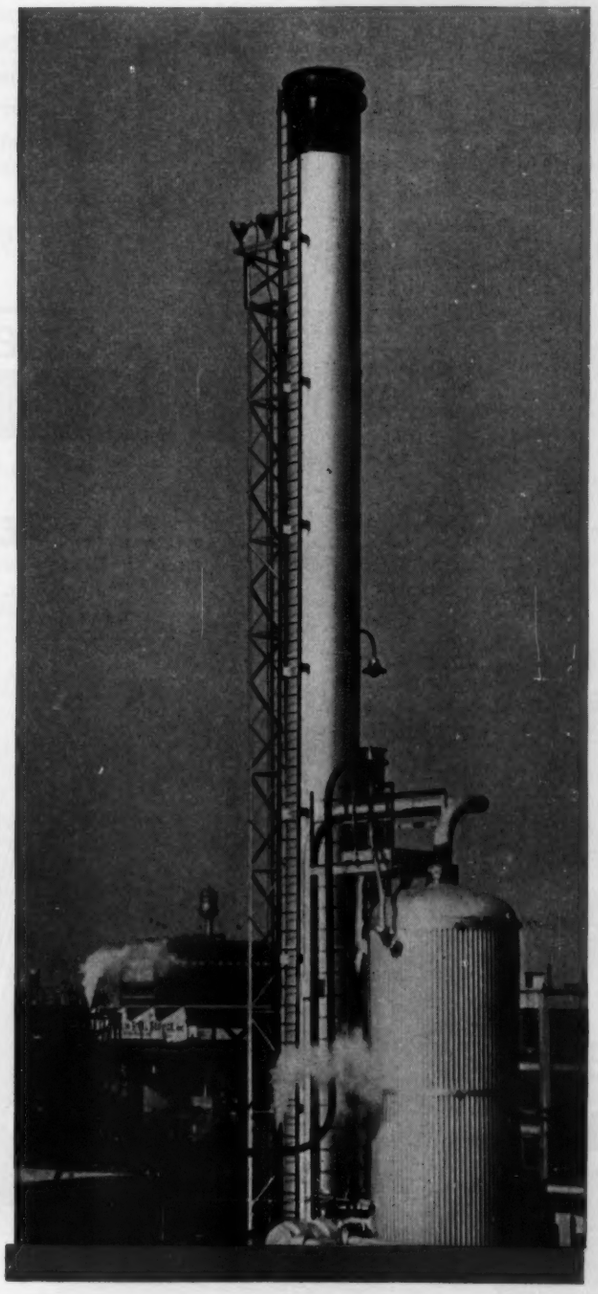
1. Consistently high yields from a once-through, low pressure operation.

2. A high octane motor gasoline with remarkable road performance and blending value.

3. A high liquid recovery which gives the refiner more of the more valuable products from a wide variety of charge stocks.

It is these three features of the Houdry Catalytic Processes which have resulted in a remarkable number of Houdry installations in a short time.

E. B. Badger & Sons Co. are Licensing Agents for the Houdry Catalytic Cracking Process.



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Engineers and Contractors
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If Your Gauges Can Take This—They Can Take Anything!

39,360 "PRESSURE JOLTS" PER DAY FOR 3 YEARS . . . . AND STILL IN PERFECT CONDITION

The Heart of the Gauge Gives Life to Its Performance

The LONERGAN refinery gauge has stamina built in. Tube is turned from specially-refined tool steel. All parts of the movement are hardened, non-corrodible steel and are mounted on an integral forged steel socket. Shoulder screws are hardened stainless steel. For pulsating pressures there is a special dampening device.

Special movements to meet specific conditions also furnished.

Think that over. Packed into a comparatively short time is service more severe than your gauges must endure in an average lifetime **and the LONERGAN Gauge shows no sign of its service age.** If that's the kind of gauge performance you're seeking . . . here it is, undeniably proved!

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GAUGES · VALVES · SPECIALTIES

300 Specialties for Power Plants
Standard Since 1872

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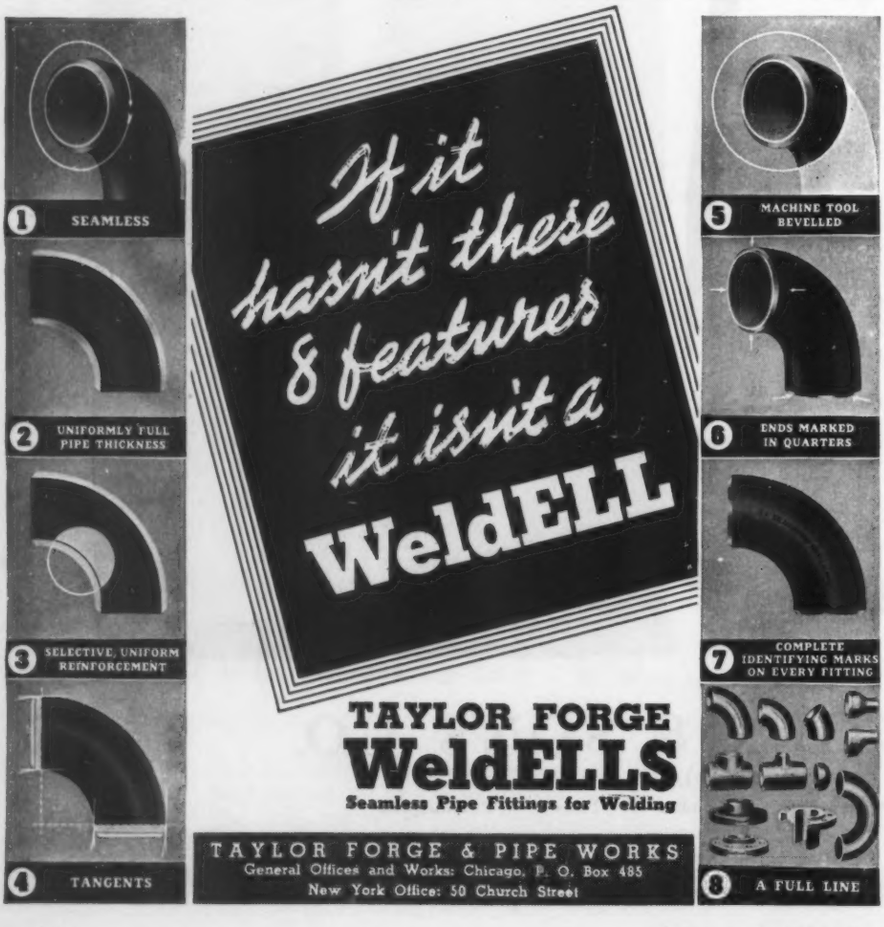
The LONERGAN line of gauges—including the new LONERGAN phenol case gauge that is moisture, dust and vapor-proof—are described fully in Catalog 600. Write for your copy and name of the nearest distributor.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If it hasn't these 8 features it isn't a WeldELL
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Seamless Pipe Fittings for Welding

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Acting Director of Bureau Named

Dr. R. R. Sayers, senior surgeon of the United States Public Health Service, has been named acting director of the United States Bureau of Mines. He fills the vacancy left when John Finch resigned. Dr. Sayers is an expert on industrial safety and hygiene.

The resignation of Finch came during the hearings on the conservation measure which was introduced in Congress by Representative Cole. While the cause of the resignation was not made public, it was common knowledge in Washington that Finch was not in sympathy with methods of Harold L. Ickes in seeking passage of the measure.

Index for A.S.T.M. Standards Published

Information on all the 885 standards of the American Society for Testing Materials has been compiled as an index, which can be had through headquarters of the organization, 260 South Broad Street, Philadelphia.

All items are listed under appropriate key words according to the subjects they cover. As a convenience a list is given of the specifications and tests in numerical sequence of their serial designations.

Laboratory Analysis Of Distillation

Analysis of crude oil by fractional distillation in the laboratory has been described in detail in a report of the United States Bureau of Mines. The paper was prepared by C. C. Ward and has been published in bulletin form.

It is treated in four parts: general consideration of fractionating unit design and operation; evaluation of columns; discussion and tabulation of details of construction, operation and evaluation of fractionating units; conclusions as to principal factors in the design of units.

Copies may be had through the government printing office, Washington, D. C., price 10 cents.

Atlantic Refining Company Honored

The Franklin Institute, Philadelphia, honored The Atlantic Refining Company April 29 in recognition of its 70 years of research and pioneer work.

The invitation gave this estimate of contributions of the company to the petroleum industry:

"Tower stills, which made commercially feasible the complete distillation of crude petroleum in one step;

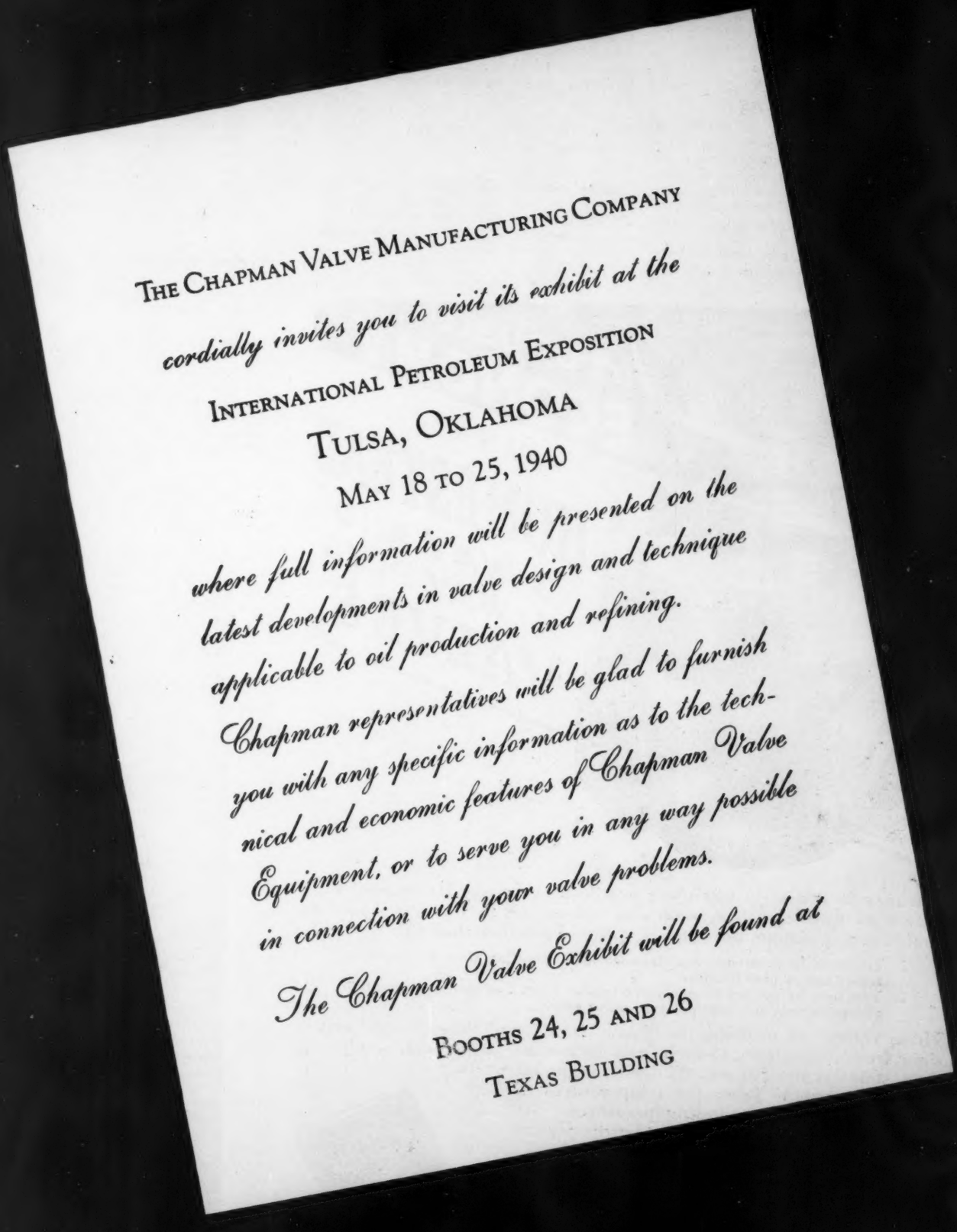
"The modern pipe still for large-scale fractional distillation of crude petroleum;

"Solvent extraction of lubrication oils;

"Thermal production of motor fuels from both heavier and lighter hydrocarbons;

"Novel developments in the construction and propulsion of ocean-going tankers;

"And now the determination of the


THE CHAPMAN VALVE MANUFACTURING COMPANY
cordially invites you to visit its exhibit at the
INTERNATIONAL PETROLEUM EXPOSITION
TULSA, OKLAHOMA
MAY 18 TO 25, 1940
where full information will be presented on the latest developments in valve design and technique applicable to oil production and refining.
Chapman representatives will be glad to furnish you with any specific information as to the technical and economic features of Chapman Valve Equipment, or to serve you in any way possible in connection with your valve problems.
The Chapman Valve Exhibit will be found at
BOOTHS 24, 25 AND 26
TEXAS BUILDING

performance characteristics of modern petroleum products in modern vehicles, providing the public with practical data on the efficient and economical operation of automobiles on the public highways."

V. L. Roberson Joins Pennsylvania Refining

Announcement has been made by Pennsylvania Refining Company, Butler, Pennsylvania, of appointment of V. L. Roberson to the position of sales manager of the Specialties Division. In his new position, he will be in charge of sales of white oil, Petrolatum, Insectisol and kindred products.

Before joining the company Roberson had engaged in marketing activity.

PLANT ACTIVITIES

Saskatchewan Plant: The 750-barrel plant of Shaw Petroleums, Ltd., at Lloydminster, Saskatchewan, was scheduled to go on stream this month as construction activities neared completion. It will process heavy Lloydminster crude into gasoline, tractor and Diesel fuels, lubricating and road oils, greases and asphalt.

Alkylation for Richfield: A $700,000 expansion and improvement program embracing an alkylation unit will be started shortly by Richfield Oil Corporation at its Watson refinery, Los Angeles.

Coutts Plant: Sweet Grass Oil & Refining Company's new 500-barrel plant at Coutts, northern Montana, was nearing completion last month. It will process Cut Bank crude.

Gulf at Philadelphia: The Philadelphia city council's public works committee last month approved changes in streets near Gulf Oil Corporation's plant. The company recently purchased 29½ acres of land, increasing its holdings to 330 acres, for a contemplated expansion program of its Philadelphia plant.

Topping at Shelby: Petroleum Refining Corporation is constructing a 1500-barrel topping plant at Shelby, Montana. Contract has been awarded to Associated Piping & Engineering Company, Los Angeles, and tanks are being installed by J. T. Sparling, Los Angeles.

Treating at Wichita Falls: Panhandle Refining Company, Wichita Falls, is installing a copper sweetening unit of 1600 barrels capacity at its Wichita Falls plant. The unit will be the solid copper process, which is licensed by Perco, Incorporated, Bartlesville, Oklahoma, and it will process straight-run refinery gasoline.

Treating at Brooks: Lone Star Gas Company, Dallas, has completed installation of a copper sweetening unit at its Brooks natural gasoline plant, Stephens County, Texas. The unit was installed under license of Perco, Incorporated, Bartlesville.

Oil From Coke: Koppers Company, Engineering and Construction Division, has been awarded a contract by the Philadelphia Coke Company, Philadelphia, for design and construction of apparatus and equipment for the production of light oils and motor fuel. Construction is to start immediately and the plant is to be completed in six months.

Catalytic at Bayonne: Tide Water Associated Oil Company has taken a license from Houdry Process Corporation for 15,000 barrels daily of catalytic refining capacity per day. Contract for the plant has been awarded to E. B. Badger & Sons Company. It will be located at the company's refinery at Bayonne, New Jersey, and will replace older facilities.

The company recently installed at its refinery in Avon, California, additional cracking facilities and a polymerization plant for the production of a gasoline of high anti-knock value and improving its straight run gasoline, and at present has in course of construction an alkylation plant at its Avon refinery for the purpose of making higher octane gasoline of aviation specifications at lower cost.

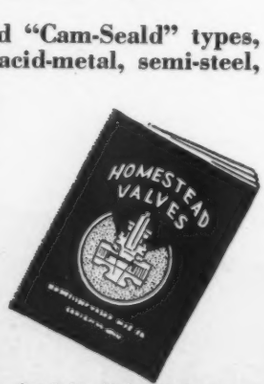
The new unit at the Bayonne refinery should be in operation toward the latter part of this year.

Cracking in Detroit: Aurora Gasoline Company, operating two plants in Michigan, has signed a license agreement with Universal Oil Products Company for a Dubbs 2-coil cracking unit

You *save* in *two ways* when you use 3-way or 4-way Homestead Plug Valves as flow changers, switching valves, or to operate single or double-acting pistons not requiring a mid-position shut-off.

1. **You save in first cost, maintenance and operating time by requiring fewer valves and fittings.**
2. **You save by getting Homestead's typical long, trouble-free operation, and extremely low cost-per-year valve service.**

These valves are available in "Lever-Seald" and "Cam-Seald" types, sizes from ½-inch to 12-inch, cast in bronze, acid-metal, semi-steel, steel, stainless steel, Monel, Ni-Resist, or special alloys for specific jobs; for temperatures to 1000° F. and corresponding pressures. Get this double economy; specify and order Homestead 3-way and 4-way Plug Valves.



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HOMESTEAD VALVES

PLANTS . . . CLARK "ANGLES"

Largest Plant in Operation—3000 H.P.—CLARK Equipped

Largest PROJECT—4000 H.P.—Also Will Be CLARK Equipped

The process of distillate extraction and recycling of high-pressure gas has been one of the major developments in the oil industry, in the past 2 years. Of the distillate plants that have been constructed and placed in operation, in this period, 7 have selected CLARK "Angles" as compressor equipment.

The largest such plant at present in operation (see opposite page), has just installed its fifth CLARK 6-cylinder, 600 H.P. "Angle," and now totals 3000 H.P. of CLARK "Angles."

And the largest projected plant in this field, which will have a capacity of 140,000,000 cu. ft. of gas (see opposite page), will be equipped with five 8-cylinder, 800 H.P. CLARK "Angles," totalling 4000 H.P.

This is just a small part of the success story of the CLARK "Angle," in its first three years on the market. In this period a new compressor sales record has been achieved, of over 100,000 H.P. sold. This success has been attributable to unsurpassed mechanical efficiency, proven reliability, and to these 4 important savings, introduced by this machine: (1) Reduced Transportation and Erection Costs, due to shipment assembled; (2) Smaller Foundation, Floor Space, Building, due to compact design; (3) One-third Fuel Saving, due to CLARK Super-2-Cycle Fuel Injection; (4) Lowest Maintenance, due to simplicity of design and few parts.

Investigate fully. Our nearest office is at your service.

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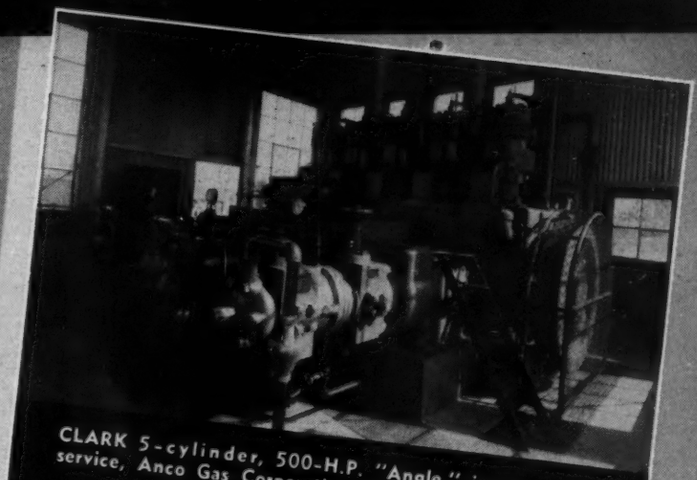
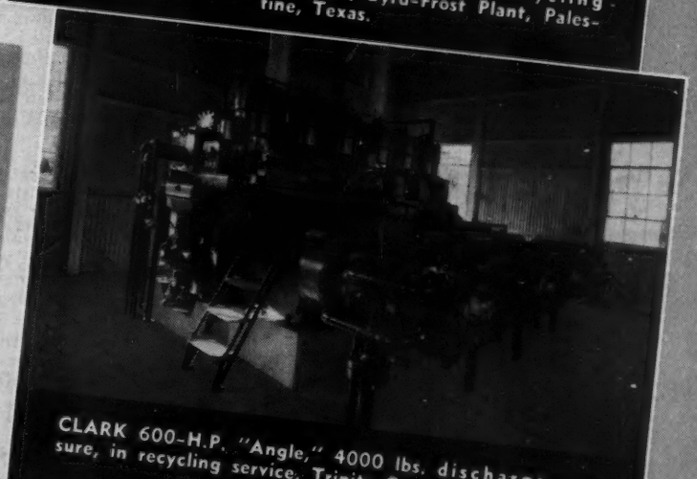
Export Office: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Texas; Chicago, Ill.; Boston, Mass. (131 Clarendon St.) West Coast Office: Smith-Booth-Usher Co., Los Angeles, Cal. Foreign Offices: 72 Turnmill St., E. C. 1, London; 4 Str. Gen. Poetas, Bucharest, Roumania.

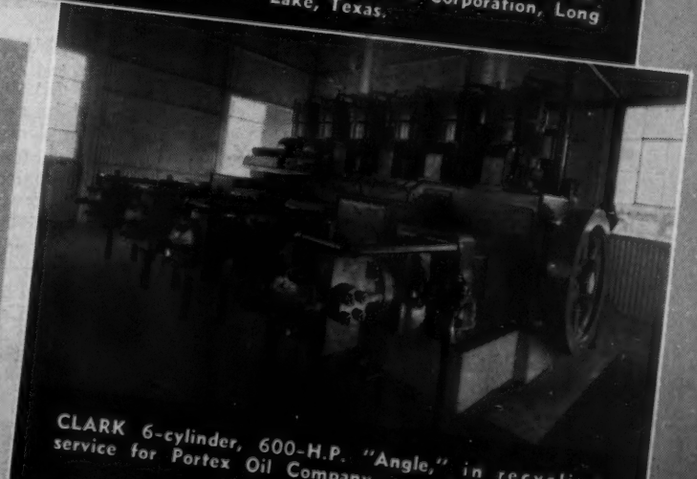
CLARK



CLARK 5-cylinder, 500-H.P. "Angle," in recycling service, Anco Gas Corporation, Byrd-Frost Plant, Palestine, Texas.



CLARK 600-H.P. "Angle," 4000 lbs. discharge pressure, in recycling service, Trinity Gas Corporation, Long Lake, Texas.



CLARK 6-cylinder, 600-H.P. "Angle," in recycling service for Portex Oil Company, near Joaquin, Shelby County, Texas.

Another OAKITE IDEA to help you save!

EASY, LOW-COST WAY TO CLEAN EXCHANGERS

FORMERLY one of the toughest jobs many refineries faced, the cleaning of heat exchanger equipment today is done much easier, faster . . . thanks to the successful, thorough, low-cost Oakite method especially developed for this work.

Just circulate through equipment a solution of recommended Oakite material as directed, then flush system thoroughly. That's all! Vigorous, fast-working Oakite action so effectively loosens carbonized oil or other heat-insulating deposits, that they are easily removed. Heat transfer efficiency is restored. Units go back in service quickly.

Save Money...Save Time ON THESE JOBS, TOO!

For cleaning Diesel cooling systems safely, stripping storage tanks and tank cars before repainting, washing drums, salvaging dirty valves and fittings, let Oakite materials and methods save time and money for you. Ask for specific data on your problems.

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OAKITE Certified cleaning
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

to be installed in the company's Detroit refinery. Construction is to begin at once.

The plant is now running 3000 barrels daily of Illinois crude. Its other refinery, located at Elsie, is processing 2500 barrels of Michigan crude. Both are skimming plants.

The Dubbs unit will have a rated charging capacity of 1800 barrels a day of topped Illinois crude. Provision will be made in the design for later conversion to a combination topping, cracking, and reforming unit with a crude capacity of 4000 barrels a day, and future addition of a U.O.P. catalytic polymerization unit is also provided for.

Contract for the work has been let to the Mid - Continent Engineering Company, Dallas. W. E. Slaughter, Jr., is president of Aurora Gasoline Company, Henry E. Wenger is vice president, and Max M. Fisher is secretary and sales manager.

Louisiana Plant Moved: Evansville Refining Company, headed by J. P. Evans, has moved its 1000-barrel plant from near Dubberly, Webster Parish, Louisiana, to Township 21n, Range 10w, also in Webster Parish. It will continue to process Sligo and Cotton Valley crude.

Recycling in Opelika Field: A permit to construct a recycling plant in the Opelika field, Henderson County, Texas, has been granted by the Texas Railroad Commission to Shamrock Oil & Gas Corporation and Lone Star Gasoline Corporation.

New Michigan Plant: Essex Refining Company has started construction on a 1500-barrel topping plant at Essexville, Michigan, with completion scheduled for June 15. The plant will process Wisner crude. Principals of the company are Elmer Brehm, Mt. Pleasant; William Allen, Wyandotte, and George Weiler and William Kerr, both of Bay City.

Plant Operating: The natural gasoline plant of the El Paso Natural Gas Company and Phillips Petroleum Company, Langlie-Mattix area, Lea County, New Mexico, was put on stream in April. It is processing gas from 408 wells and has absorption capacity of 75,000,000 cubic feet daily. An experimental repressuring project will be started in connection with plant operation and extended if found successful.

Edwards Re-elected Valvoline Head

E. W. EDWARDS, Cincinnati, was re-elected chairman of the board of Valvoline Oil Company when the company held its annual meeting at Edgewater New Jersey, last month.

Also re-elected were H. W. Edwards, board vice chairman; G. P. Doll, president and general manager; P. J. Leroux, treasurer, and C. P. Gould, secretary and assistant treasurer.

C. W. Georgi has joined Quaker State Oil Refining Corporation as director of the research laboratory at the Emlenton plant. He was formerly chief chemist for Enterprise Oil Company.

Come see us at Booths 78-79 Texas Bldg. Tulsa Show

. . . if interested in the latest equipment and methods for continuous treating in transit.

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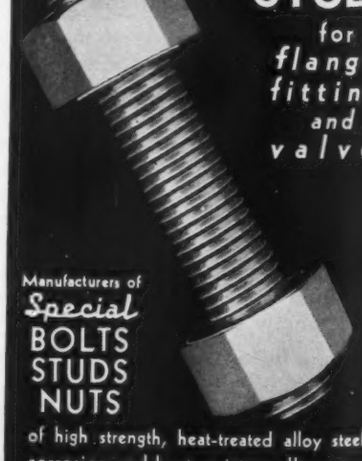

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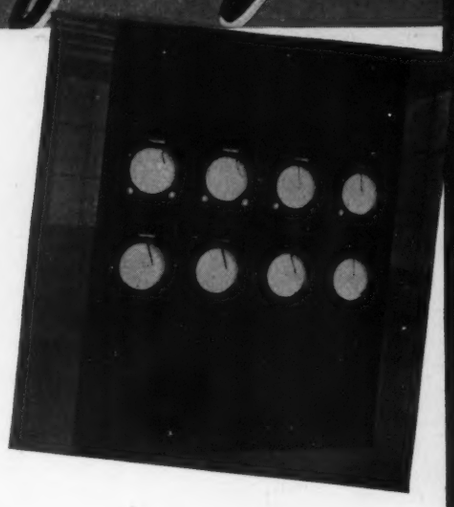

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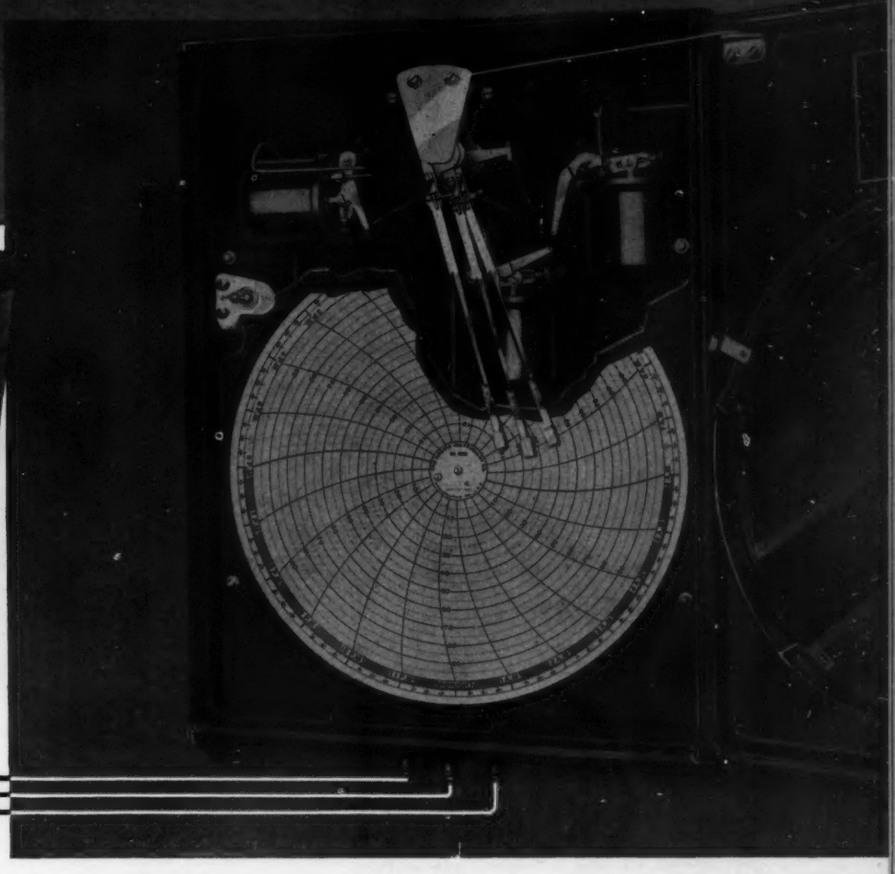

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SCIENCE AND TECHNOLOGY

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REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included. Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical Compositions And Reactions

Solid Naphthenic Acid from Iranian Petroleum, T. KENNEDY, *Nature* **144** (1939) p. 832.

It is only recently that individual naphthenic acids have been isolated in a pure condition. Many previously reported as pure have been proved to be mixtures of substances. Examination of the sulfur dioxide extract from an Iranian kerosene revealed unexpectedly the presence of approximately 0.025 percent of naphthenic acids, of which about 10 percent was removed by a light caustic wash. The spent washings from 2000 gallons of extract were neutralized and the precipitated oil was processed. The tertiary acids were separated from the acidic material, and on standing a few days yielded a white crystalline solid which upon analysis proved to have the empirical formula $C_{16}H_{18}O_2$. The structure of the compounds is discussed.

Catalytic Alkylation of Isobutane with Gaseous Olefins, F. H. BLUNCK AND D. R. CARMODY, *Ind. & Eng. Chem.* **32** (1940) pp. 328-30.

In the investigation catalysts were used in effecting the union of isobutane with the olefins ethylene, propylene, and isobutylene. At 1000 pounds per square inch pressure and about 400° F., isobutane reacts with gaseous olefins under the influence of double chlorides of aluminum and alkali metals, particularly sodium aluminum chloride and lithium aluminum chloride. The alkylation reaction is accompanied by a varying but considerable amount of polymerization and by extensive rearrangements that lead to the production of products not explicable on any simple theory. The life of the catalyst is short, and the alkylation reaction declines more rapidly than polymerization. Higher temperature favors alkylation but further decreases catalyst life. The potassium compound was not found to be active. The apparatus and procedure are described in some detail.

Catalytic Dehydrogenation of Monoolefins to Diolefins, A. V. GROSSE, J. C. MORRELL, AND J. M. MAVITY, *Ind. & Eng. Chem.* **32** (1940) pp. 309-11.

Monoolefins were dehydrogenated catalytically to give conjugated diolefins. The diolefins formed were 1,3-butadiene from n-butenes, isoprene from the branched-chain pentenes, and piperylene from 2-pentene. The once-through yields varied from 11 to 30 percent, and the ultimate yields of 1,3-butadiene up to 79 percent. Cyclopentadiene was obtained by dehydrogenating cyclopentane. It is noted that by such methods synthetic rubber can be made from large sources of raw materials such as natural and cracked gases, and the pentanes in natural gasoline and in crude petroleum.

Dehydrogenation and Nitration of Hydrocarbons of the Cyclopentane Series, E. BERL AND R. RAAB, *Ind. & Eng. Chem., Anal. Ed.* **12** (1940) p. 177.

Experiments were undertaken to determine the truth of Zelinsky's statement that hydrocarbons of the cyclopentane series are not dehydrogenated with palladium or platinum, but that only members of the cyclohexane series can be so dehydrogenated. Results of the work indicate that Zelinsky was correct in his contention.

Dihydronaphthalene Polymers, N. D. SCOTT AND J. F. WALKER, *Ind. & Eng. Chem.* **32** (1940) pp. 312-15.

A series of new hydrocarbon polymers has been made by polymerization of the isomeric dihydronaphthalenes with sodium naphthalene. From 1,4-dihydronaphthalene, light-colored thermoplastic resins are obtained. From 1,2-dihydronaphthalene infusible polymers are produced which, although completely insoluble in most solvents, form colloidal solutions in some halogenated aromatics. By the action of 80 percent sulfuric acid on 1,2-dihydronaphthalene, the substance is converted into a mixture of dihydronaphthalene dimers. 1,4-dihydronaphthalene is conveniently prepared as previously reported by the reduction of naphthalene with sodium and alcohol. It may also be made by the hydrolysis of sodium naphthalene. This isomer is rearranged to 1,2-dihydronaphthalene by action of sodium ethylate.

Nitration of Ethane, H. J. HIBSHMAN, E. H. PIERSON, AND H. B. HASS, *Ind. & Eng. Chem.* **32** (1940) pp. 427-9.

The study of the nitration of the hydrocarbon ethane was undertaken because certain derivatives of nitromethane and nitroethane are high explosives. The trinitrates of 2-hydroxymethyl-2-nitro-1,3-propanediol and the dinitrate of 2-methyl-2-nitro-1,3-propanediol have been tested as high explosives by previous workers and have been reported to be of value. By careful control of conditions for the nitration of ethane it is possible to raise the 9 percent conversion previously reported to 33 percent, based on nitric acid. This corresponds to an over-all yield of more than 90 percent in a process that includes reconversion of nitric oxide to nitric acid. The nitration is a homogeneous, vapor-phase reaction and yields a ratio of nitromethane to nitroethane of 27 to 73 by weight. By a suitable combination of this synthesis with other known processes, it is now possible to produce these high explosives from air, steam, and natural gas as the ultimate raw materials. The apparatus used is described, and the reactions are discussed.

Oxidation of Thiophen-Sulphur by Calcium Hypochlorite Solutions, E. G. R. ARDAGH, W. H. BOWMAN, AND A. S. WEATHERBURN, *Jour. Soc. Chem. Ind.* **59** (1940) pp. 27-8.

Factors influencing the proportion of thiophen-sulphur converted into sulphate as a result of the oxidation action of calcium hypochlorite solutions are discussed. The range of pH values found most effective for the oxidation of thiophen by this method lies in the neighborhood of 8 to 7. Such average pH values for the Hypochlorite solution will result in the use of an initial pH of 8, or, for longer periods of treatment, pH 9. The use of other acidifying agents for the adjustment of the initial pH gave essentially the same results as acetic acids. Conditions were found in which over 90% of the thiophen sulphur was oxidized to sulphate ion by hypochlorite solutions.

Fundamental Physical and Chemical Data

Phase-Equilibria in Hydrocarbon Systems, R. A. BUDENHOLZER, B. H. SAGE, AND W. N. LACEY, *Ind. & Eng. Chem.* **32** (1940) pp. 384-7.

The Joule-Thomson coefficient is of utility in the evaluation of the thermodynamic behavior of gaseous mixtures. Joule-Thomson coefficients for five mixtures of methane and n-butane were determined experimentally at five temperatures between 70° and 310°F. at pressures between 50 and 1500 pounds per square inch absolute. From these data, together with the isobaric heat capacity at infinite attenuation, the heat capacities of several mixtures were calculated as functions of pressure and temperature. The results are presented in graphical and tabular form.

Phase Diagram of a Mixture of Natural Gas and Natural Gasoline Near the Critical Conditions, D. L. KATZ, D. J. VINK, AND R. A. DAVID, *Petrol. Tech.*, November, 1939, A.I.M.M.E., Tech Pub. No. 1114.

A phase diagram showing boundary curve and quantity of liquid in the two-phase region was determined for a mixture of natural gas and natural gasoline in the critical regions. The range of temperatures and pressures covered by the measurements were 85-212°F. and 1300/2600 lbs. per sqare inch. The critical conditions were 169.5°F. and 2615 lbs. per square inch absolute. Striking color phenomena were noted near the critical region. At pressures considerably above the two-phase region the system was colorless. As the pressure was lowered toward the bubble or dew point the single phase became reddish. At temperatures near the critical the color was a bright mahogany red. No unusual change was observed in the shape of the pressure-volume curves for the two-phase system in passing from temperatures below the critical to the region of retrograde condensation. The curve of saturated density appears to be smooth for the bubble-point liquid below the critical temperature and for the dew-point vapor above the critical temperature.

Liquid-Vapor Equilibrium Relations in Binary Systems, W. B. KAY, *Ind. & Eng. Chem.* **32** (1940) pp. 353-7.

The P-V-T-x relationships at the liquid- and vapor-phase boundaries in the system ethane-n-butane were determined from measurement on a series of solutions varying in composition from pure ethane to pure n-butane. The T-x diagrams of the coexisting liquid and vapor at constant pressure were constructed, and a comparison was made with diagrams computed by means of the solution laws. The results indicate definitely that the solution laws are inadequate for the calculation of these relationships at high pressures. Vapor-liquid equilibrium constants were obtained for ethane and n-butane. Information on the effect of composition as well as of temperature and pressure on the equilibrium constants of ethane is given. This was obtained by making a comparison of the constants for ethane dissolved in n-butane with those for ethane dissolved in n-heptane. The

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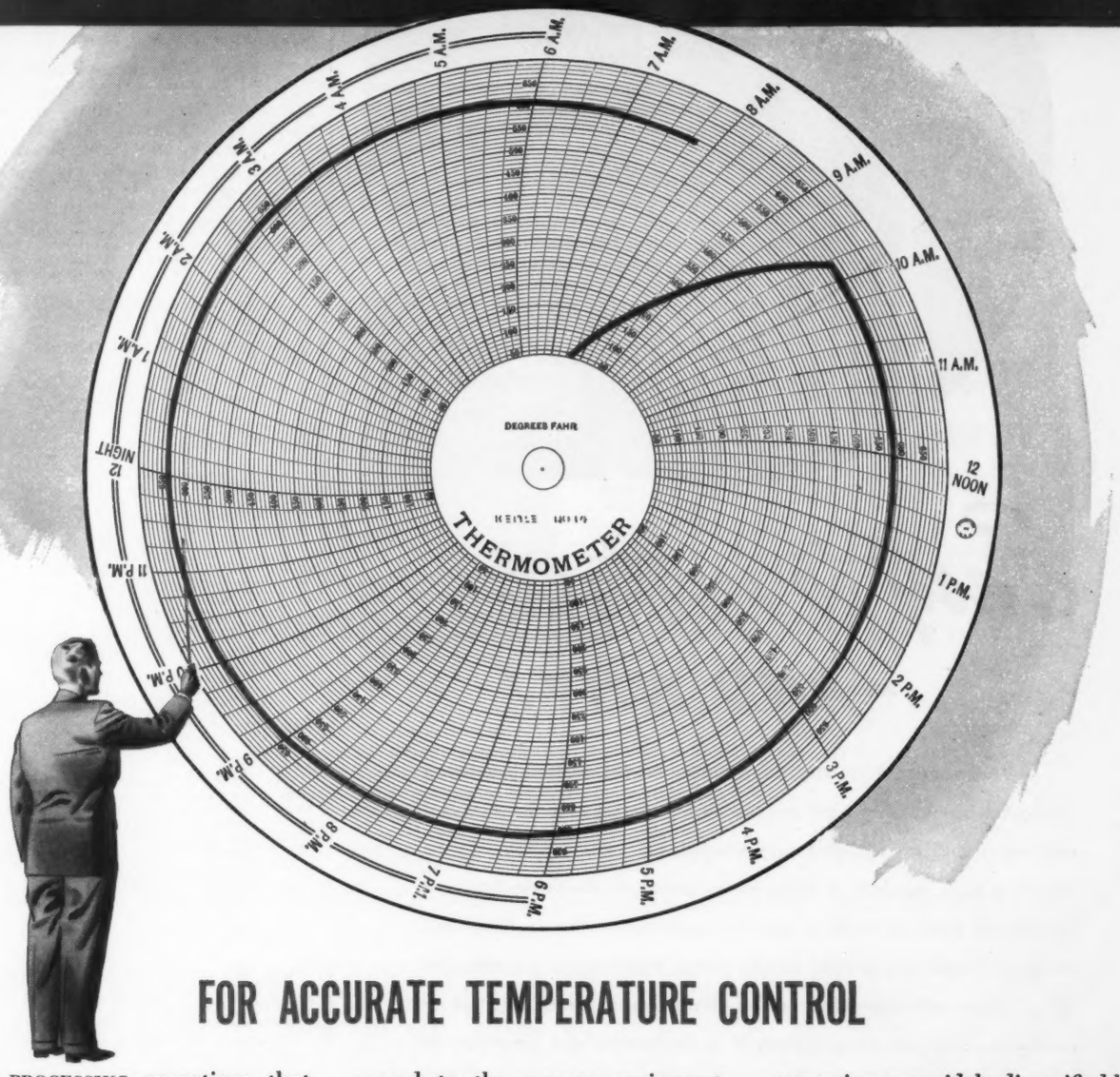

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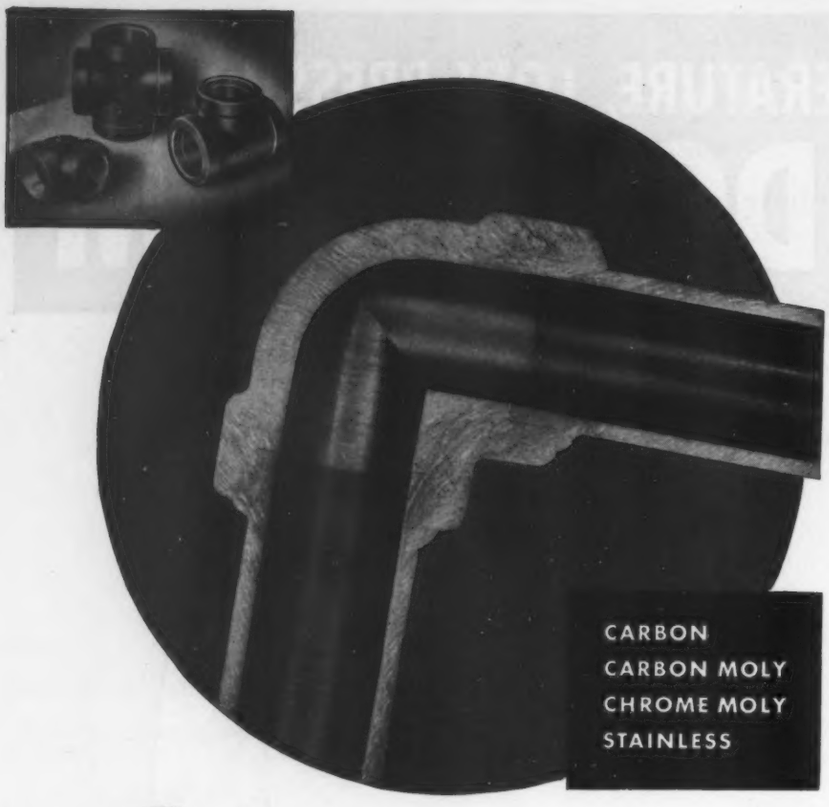

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apparatus, methods of procedure, and results are given in detail.

Pressure-Volume-Temperature Relations for n-Butane, W. B. KAY, *Ind. & Eng. Chem.* **32** (1940) pp. 358-60.

In the course of the study of the system ethane-n-butane the following properties of n-butane were measured: (a) the vapor pressure and densities of the saturated liquid and vapor from room temperature to the critical point; and (b) the compressibility of the liquid and vapor from 100° to 600°F. and 35 to 1200 pounds per square inch. The critical temperature and pressure were found to be 306.0°F. and 550.1 pounds per square inch, respectively. By extrapolation of the mean density line to the critical temperature the value of 14.24 pounds per cubic foot was obtained for the critical density.

Entropy of Dimethylacetylene from Low-Temperature Calorimetric Measurements. Free Rotation in the Dimethylacetylene Molecule, D. W. OSBORNE, C. S. GARNER, AND D. M. YOST, *J. Chem. Phys.* **8** (1940) pp. 131.

The molal entropy of MeC:CMe at 291.00°K. and 536 mm. is 68.14 cal./deg. mole from calorimetric data, and 67.82 cal./deg. mole from molar data. This close agreement indicates that there is no appreciable barrier restricting the rotation of the methyl groups with respect to each other in the molecule.

Isothermal Changes in Enthalpy for Some Gases, R. YORK, JR., AND H. C. WEBER, *Ind. & Eng. Chem.* **32** (1940) pp. 388-92.

Using data for ethane, propane, carbondioxide, benzene, the authors correlate isothermal changes with pressure of enthalpy by the empirical relation $(H^{\circ}-H)_T=\triangle_1 T_c (T_c/370)^n$, the value of n can be determined from a diagram constructed for the purpose, and appropriate values for $\triangle_1$ can be read from a second diagram given in the article. The authors conclude that although it is apparent that a correlation for all substances has not yet been obtained, the method proposed gives satisfactory values for those substances studied. The correlation given fits neither the gases of low-boiling liquids nor the so-called highly polar compounds. However, it is believed that the correlation is reliable between $T_R=1.00$ and $T_R=1.80$ and between $P_R=0$ and $P_R=8$ for hydrocarbons with critical temperatures between 300° and 600° K.

Analytical Calculations of Thermodynamic Properties, H. M. ROBINSON AND H. BLISS, *Ind. & Eng. Chem.* **32** (1940) pp. 396-8.

Equations for calculating entropy, enthalpy, and energy changes in terms of volume have been derived for the Van der Waals, Wohl, and Beattie-Bridgeman equations of state. They have been tested for entropy and enthalpy calculations by comparisons with published data on methane, propane and nitrogen. The Beattie-Bridgeman equation is satisfactory to within 5-7 percent for entropy and 12 percent for enthalpy determinations. The other equations are almost as good for entropy calculations but definitely inferior for the determination of enthalpy.

Specific Heat Ratios for Hydrocarbons, W. C. EDMISTER, *Ind. & Eng. Chem.* **32** (1940) pp. 373-5.

The ratio of isobaric to isometric specific heats, $C_p/C_v=\gamma$, is an essential thermodynamic property in calculations involving the adiabatic compression or expansion of a gas. A chart is presented for estimating $C_p/C_v(\gamma)$ ratios for methane, ethylene, ethane, propylene, propane, isobutylene, isobutane, 2-butane, n-butane, isopentane, n-pentane, benzene, diisopropyl, n-hexane, n-heptane, diisobutyl, and n-octane at reduced pressures up to 1.2 and at reduced temperatures up to 2.5.

Pressure and Temperature Effects on the Viscosity of Liquids, D. FRISCH, H. EYRING, AND J. F. KINCAID, *J. Applied Phys.* **11** (1940) pp. 75-80.

The free energy of activation for viscous flow is related to entropy and energy of activation by the same equations as any equilibrium and is perfectly general and independent of the mechanism. Equations are developed for a bimolecular flow process in which pairs of molecules lying in adjoining layers roll over each other. At low pressures the heat of activation for viscous flow is about 1/3 the energy of vaporization, but as pressure is raised it increases rapidly because of the work term PV/n'. Calculations for n- and iso-pentane, ethyl ether, benzene, water, and mercury, over pressures ranging from one

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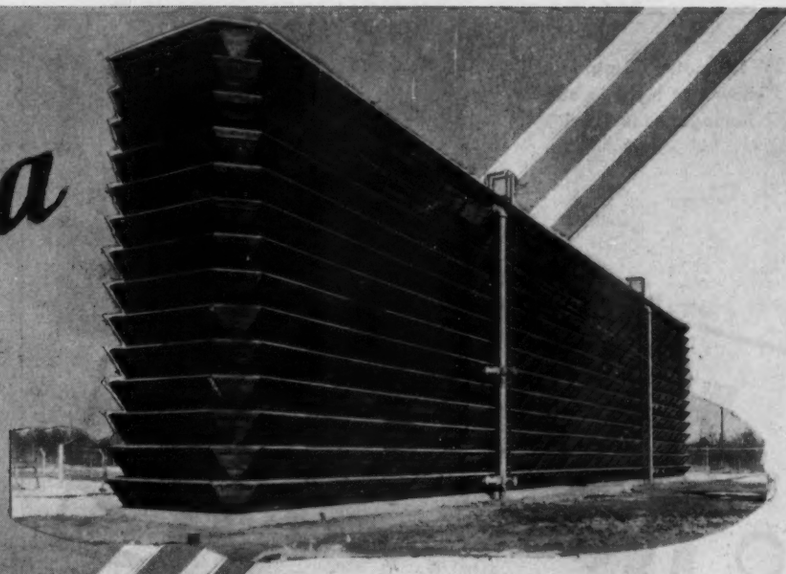

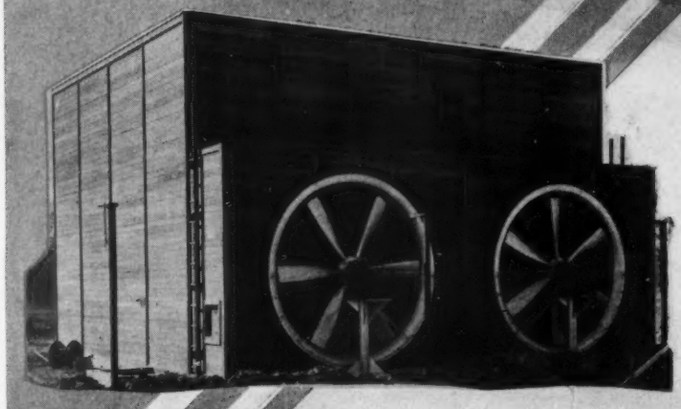

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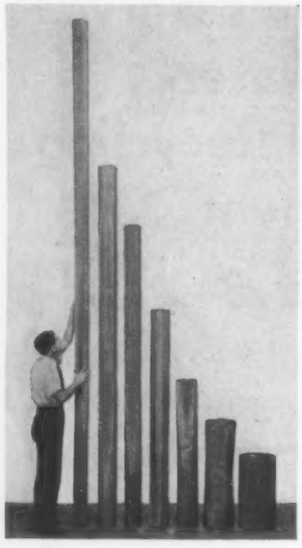

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A Practical Manual of Chemical Engineering, H. TONGUE, with Foreword by SIR GILBERT MORGAN, pp. xv., 560, Chapman and Hall, Ltd., London. Price 36s.

This recent British book in the field of chemical engineering considers the materials of construction, both metallic and non-metallic, at some length. The methods of fabricating materials, including the design of pressure vessels, on which subject the author has written a separate book, occupies about a third of the present volume. The other chapters deal with the subject of piping, heat insulation, boiler plants, fluid flow, heat transfer, evaporation, drying, adsorption, distillation, filtration, crushing and grinding, and pumping.

Pressure Gradient Fractionation of Gases, J. W. CREELY AND G. C. LE COMPTE, *Ind. & Eng. Chem.* **32** (1940) pp. 430-4.

The authors review the subject of the separation of gases by fractionation. Equations are developed to show the distribution of a multicomponent gas between a solvent and a liquid phase, the pressure gradient fractionation of a multicomponent gas mixture dissolved in a solvent, a perfect countercurrent continuous pressure gradient fractionation of a multicomponent gas mixture, and a theoretical pressure gradient fractionation plate for a gas of two components.

Polybutenes, R. M. THOMAS, J. C. ZIMMER, L. B. TURNER, R. ROSEN, AND P. K. FROLICH, *Ind. & Eng. Chem.* **32** (1940) pp. 299-304.

The appearance of the polybutenes varies according to their molecular weight. The low polymers are liquids, intermediate polymers are clear, sticky and viscous fluids; the high polymers are ordinarily white, tough, and elastic solids, although they are colorless in a degassed state. The polymers are obtainable through the polymerization of butenes at low temperatures. At ordinary temperatures the high polymers are chemically inert and of stable character. In general, they are most readily dissolved in liquid aliphatic hydrocarbons and certain chlorinated hydrocarbons. Dilute solutions of the polymers are employed for the estimation of the average chain length of the molecules by the viscosity method. Low molecular weight polymers dissolve in a light and well-refined lubricating oil are available for increasing the viscosity index of motor oils. The higher molecular weight polybutenes are used extensively as concentrated solutions in a base oil for making of greases, and for non-leaking textile lubricants. As additions to asphalt the polybutenes give higher values for the softening point, accompanied by an increase in penetration, so that the softening point-penetration relationship is improved. Ductility values are somewhat lower. The properties of crystalline of amorphous paraffin wax are changed by the addition of polybutenes. As a result of viscosity increase the strike-through is reduced. This is of importance in coating goods with wax when only a film on the outer surface is desired. The low-temperature properties of waxes can be improved in the sense of reducing their brittleness by the addition of polybutenes. Adhesive waxes can also be made. Reference is made to other miscellaneous uses of these compounds.

Production of Petroleum Resins, S. C. FULTON AND A. H. GLEASON, *Ind. & Eng. Chem.* **32** (1940) pp. 304-9.

Resins occur naturally in crude oil in small amounts. However, resins can be formed during the processing of crude oils and by direct synthesis from various fractions. Resins in cracking-coil tar may be recovered directly by absorption, but it has been found preferable to subject the tar to distillation and solvent extraction. Treatment of the reduced tar with metallic halides is especially advantageous both for increasing the yield of resins and causing separation of undesirable components. Petroleum distillates, and particularly those of high aromatic hydrocarbon content, may be condensed with formaldehyde to form useful resins. Less highly aromatic stocks may be partially converted to resinous material by chlorination, followed by dehydrohalogenation either at elevated temperatures or through the use of metallic halides.

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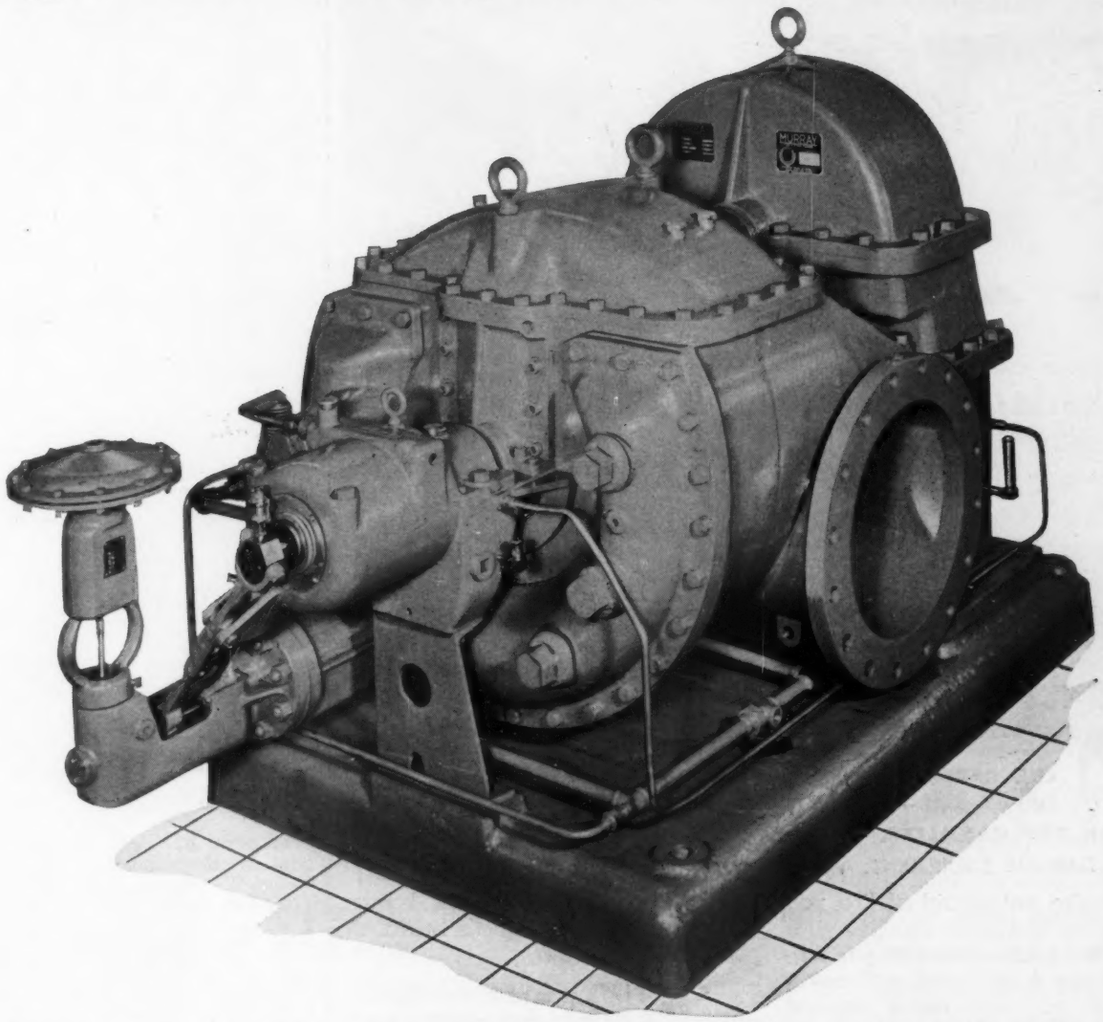

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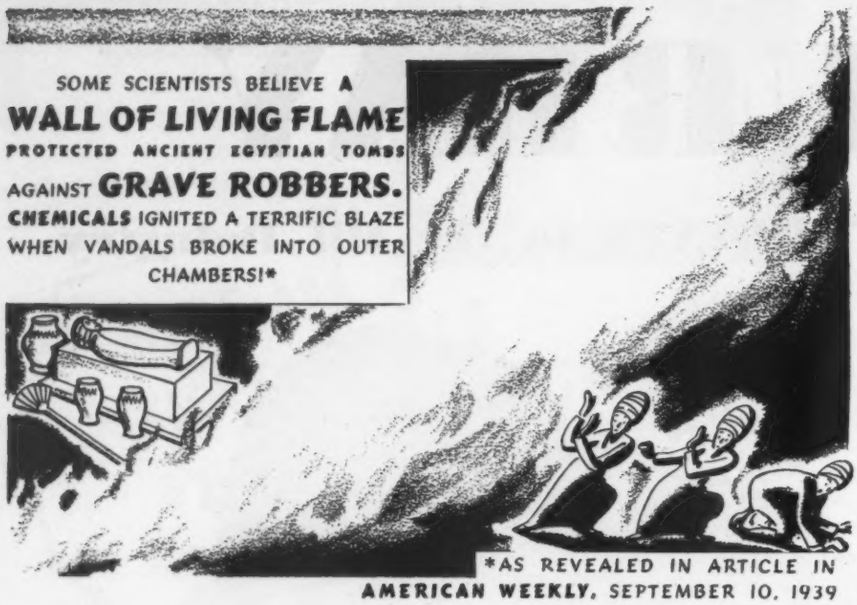

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ADDRESS_____

The authors conclude that it appears possible to produce a variety of resins from petroleum sources with more or less chemical processing, and that these will cover a range in quality and production costs. The physical and chemical properties of the resins are such as to make them appear interesting for application for a variety of purposes.

Propane Precipitation of Petroleum Resins, P. T. GRAFF AND H. O. FORREST, *Ind. & Eng. Chem.* **32** (1940) pp. 294-8.

Resins can be separated from crude oil residuals and heavy distillates by means of propane precipitation. Because of the high molecular weight and high boiling point of these resins, it has been difficult to separate them from petroleum on a commercial scale. The separation with propane is conducted at moderate temperatures, and therefore no injury to the resin components of the crude oil results. Color bodies, carbon-forming material, and some asphaltenes are found in the resin products. In addition, high-viscosity oil fractions separate with the resin material, the oil comprising high-molecular-weight naphthenes and paraffins. The quantity, and in some measure, the quality of the oil so included can be controlled by the temperature of separation and the propane solution ratio. One or more additional stages of settling in propane solution will subdivide the product into oils and a resinous residue. Data are included on the properties of the various products.

Solubility of Cracked Residues in Some Solvents, J. VOSKUIL, *Jour. Inst. Petr.* **26** (1940) pp. 57-71.

The paper deals with a continuation of the investigation of the shape of the precipitation curves and the solubility of cracked residues in solvents frequently used in practice. When cracked residue and fuel oil containing cracked residues are diluted, a precipitant hydrocarbon, and percentages of precipitate are plotted against the dilution, precipitation curves are obtained. These lines are practically horizontal at high dilutions with aliphatic solvents and with cyclohexane. When adding large amounts of benzene to a cracked residue, some precipitate is also formed. If the cracked residue contains sludge, small quantities of benzene may peptize part of the sludge, whereas larger amounts of benzene may increase the amount of precipitate, so that the precipitation curve has a minimum. In the second part of the article a comparison is made between the percentages of benzene-insoluble in residues highly diluted with benzene, and in these materials after a Soxhlet extraction of the pentane-insoluble portion with solvents increasing in solvent power up to that of benzene. The extraction method was found to give higher values than the dilution method. The colloid-chemical nature of the cracked residue is considered as clearly demonstrated.

Products: Properties And Utilization

Modern Problems in Internal-Combustion Engineering, W. J. WALKER, *Trans. S. African Inst. Elec. Engrs.* **30** (1939) p. 116.

A new theory for the knocking of fuels proposes that nuclear points of combustion act in the same manner as electron emission devices that energize the air and form ozonides that are explosive. This leads to secondary combustion. Colloidalized lead stabilized with 0.25% rubber gave pronounced anti-knock properties. Detonation problems in gas, oil, and Diesel engines are considered.

Chem. & Met. Report on Plant Lubrication, Series A, No. 2, *Chem. & Met. Engr.* **47** (1940) pp. 171-8.

The editors of Chemical and Metallurgical Engineering present a survey of the field of lubrication in chemical plants. This includes a discussion of the elements of lubrication that includes consideration of the mechanism of lubrication and why it is necessary to lubricate. A discussion of the properties of lubricants includes sources of lubricants and the outstanding properties and tests of lubricants, the significance of viscosity, viscosity index, demulsibility, carbon residue, flash point, and other properties, are briefly considered. Under the general subject of the application of lubricants, thin-film and fluid-film lubrication are discussed, methods of lubricating and the principal types of lubricating devices are considered, the storage and handling of lubricants is included, and care in storage is emphasized. Under discussion of the chemical factors in lubrication the editors deal with those specialized problems that occur in the chemical industry where usual lubricating procedure is not applicable. Special situations are caused by the presence of corrosive or solvent chemicals,

Ask the engineers who have sought a solution to the problem of *smooth* petroleum-plant control and they'll confirm the fact that there's just one term on the right hand side of the equation: Stabilog. Its full-range throttling action, practical service dependability and adaptability to critical control requirements involving temperature, pressure, flow, liquid level have made it possible to cancel out the unknown factors influencing plant efficiency. What's more, there's no occasion for "nursing" or other hand adjustments with Stabilog control. » » » Why not stop in at Booths 3-4-5 at the Petroleum Exposition and ask a Foxboro representative how to apply this equation to your own individual control problems on the basis of practical experience at other plants? **The Foxboro Company, 74 Neponset Avenue, Foxboro, Massachusetts, U.S.A.** Branches in 25 Principal Cities.

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Instrumentation

of poisonous gases, or of unusual materials of construction, of extreme conditions of temperature and pressure, as well as exacting requirements of purity of product. The article closes with a condensed bibliography to serve as an aid to those who wish to study the subject further.

Recent Developments in Diesel Lubricating Oils, G. L. NEELY, *J. Soc. Aut. Engrs.* 45 (1939) pp. 485-500.

The author describes the development of a new compounded diesel lubricating oil. The base stock is especially treated naphthenic-base oil. The development work involved prolonged tests on five makes of engines using eight sets of test conditions. Loads ranged from 2.5% to 150% of rated power and jacket temperatures from 80°F. to 375°F. The results given in the paper are confined to four compounded oils and one straight mineral oil. The use of compounded oils leads to a marked reduction of piston deposits and ring-sticking, but many addition agents cause corrosion of non-babbitt bearings. However, a non-corrosive lubricant was developed that gave excellent results in a prolonged ring-sticking test. This same oil showed a low rate of cylinder wear both under high- and low-temperature operating conditions. In comparison, the straight mineral oil showed much greater wear. It is believed that the piston ring temperatures in many diesel and aircraft engines exceed the limiting adhesion temperatures of the oils commonly used. Diesel lubricants containing anti-ring-sticking agents may be employed to free piston rings and remove piston-deposits that have been caused by previous use of unsuitable oils. The author claims that a compounded diesel lubricant is now available having all of the following properties: (1) anti-ring-sticking value; (2) non-corrosivity; (3) low wear at both high and low temperatures; (4) good breaking-in properties, and (5) high stability in both storage and service.

The Catalytic Effect of Metals on the Ageing of Lubricating Oil for Diesel Engines, H. L. MATTHIJSEN, *Jour. Inst. Petr.* 26 (1940) pp. 72-90.

The object of the work was to determine the catalytic effect of metals on the ageing of lubricating oil. During the examination at regular intervals of the used lubricating oils from the Maybach engines of the Diesel trains of the Netherlands Railways, the question was raised as to whether the small metal splinters present in the used oil increase or reduce the content of oxidation- or ageing-products. A bibliography on the general subject of the effect of metals is included, and also one on the literature on the ageing of lubricating oils. Twenty-three different laboratory oxidation methods have been used. Since it was not possible to do the work in the engines of the diesel trains, the experiments were made using a laboratory oxidation instrument designed by Mr. A. Mollinger The apparatus and the method of using it are described. The results are not considered conclusive, although the results of the oxidation tests agree in general with those observed in practice in the diesel engines. The results of oxidation tests using 78 lubricating oils show that pure Pennsylvania oils age least of all, and in this test are superior to the naphthene base oils. Many solvent treated oils were found to age considerably. Forty-one oils were tested also by the Indiana oxidation test. In the case of 27 oils the results agreed well with those secured by the Mollinger apparatus; with the remaining 14 oils, however, the comparison turned out badly. The test indicated that all the ferrous metals stimulate ageing in some measure. The non-ferrous metals have no catalytic effect, or a negative one. With the paraffin base oils, copper had a slight positive effect up to 180°C. but above that temperature, strongly repressed the ageing. With a naphthene base oil, copper has a slight catalytic effect over the entire temperature range.

Modern Road Emulsions, F. H. GARNER, L. G. GABRIEL, AND H. J. PRENTICE, *2nd Edition, 1939,* pp. xv., 245. The Road Emulsion and Cold Bituminous Roads Assn., Ltd., London. Price 10s.

The book is a second and revised edition of one that first appeared in 1933. The first half of the work is concerned with the road emulsions and their uses. The second half includes tests and specifications, both British and foreign. Two appendices cover the subjects of the Determination of the Size-Frequency Curve of Emulsion Particles, and Average Diameter of Particles. The book also includes a glossary of terms, an excellent bibliography and a collection of 26 tables of data of practical use.

Effect of Petroleum Products on Neoprene Vulcanizates, D. F. FRASER, *Ind. & Eng. Chem.* 32 (1940) pp. 320-3.

When immersed in commercial lubricating oils, neoprene vulcanizates reach equilibria with respect to swelling or volume increase. The time necessary to reach equilibrium depends upon the immersion temperature and the chemical characteristics of the oil. It is shown that the volume increase of a neoprene compound in lubricating oils is a logarithmic function of the viscosity-gravity constants, or a direct function of the gravity indices. The volume increase appears to be independent of the refractive and viscosity indices of the oils.

Determination of Saturated Hydrocarbons, E. BERL AND W. KOERBER, *Ind. & Eng. Chem., Anal. Ed.* 12 (1940) pp. 175-6.

A method is described for the determination of saturated aliphatic, aromatic, and hydroaromatic hydrocarbons of the cyclohexane series in mixtures of these hydrocarbons. The method is based on the nitration of the solution with a special mixed acid that affects only aromatic hydrocarbons, converting them into monomitro derivatives that are soluble in the mixed acid. As a second step the hydrocarbon solution is dehydrogenated at high temperature by use of a platinum catalyst that converts the hydroaromatic hydrocarbons into aromatic hydrocarbons. A subsequent nitration gives the mononitro products from the original aromatics plus the aromatics formed by dehydrogenation. The method can be used for analyzing small quantities, and the time required is short.

Circuit Breakers

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania, has issued an 8-page leaflet, designated No. 33-555, describing its Type F-75 indoor oil circuit breakers with interrupting capacities of 75,000 KVA. The equipment is designed especially for use in generating stations and industrial plants where minimum space is available for switching equipment. They may be operated either manually or electrically, and are available in ratings of 600, 1200 and 2000 amperes, at voltages of 15,000, 7500 and 5000 volts, respectively.

M·S·A
SALT TABLET DISPENSERS

Production as usual in hot summer weather, minus the bugaboo of "heat sickness", is found in the refineries and field where M.S.A. Salt Tablets are available! Three new and outstanding efficient M.S.A. Dispensers, ranging from the handy One-at-a-Time metal pocket unit through the "350" and "1500" Dispensers—made of corrosion-proof and breakage-resistant Bakelite, dustproof and weatherproof—provide in easy to take tablet form the salt necessary to replenish that lost from the body by profuse sweating. Write for the details on these positive Dispensers of one salt tablet at a time, every time!

M.S.A. FIRST AID KITS
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Weatherproof, dustproof, sealed against dirt and moisture, M.S.A. All-Weather First Aid Kits offer complete protection to their individual unit-package contents of first aid materials. The extra-rugged cases of welded sheet steel are designed for hardest service, and are equipped with replaceable, flat molded rubber gaskets —brackets for wall or vehicle mounting are supplied on request at no extra cost. M.S.A. supplies a complete line of first aid materials and equipment for every refining need. Write for descriptive literature!

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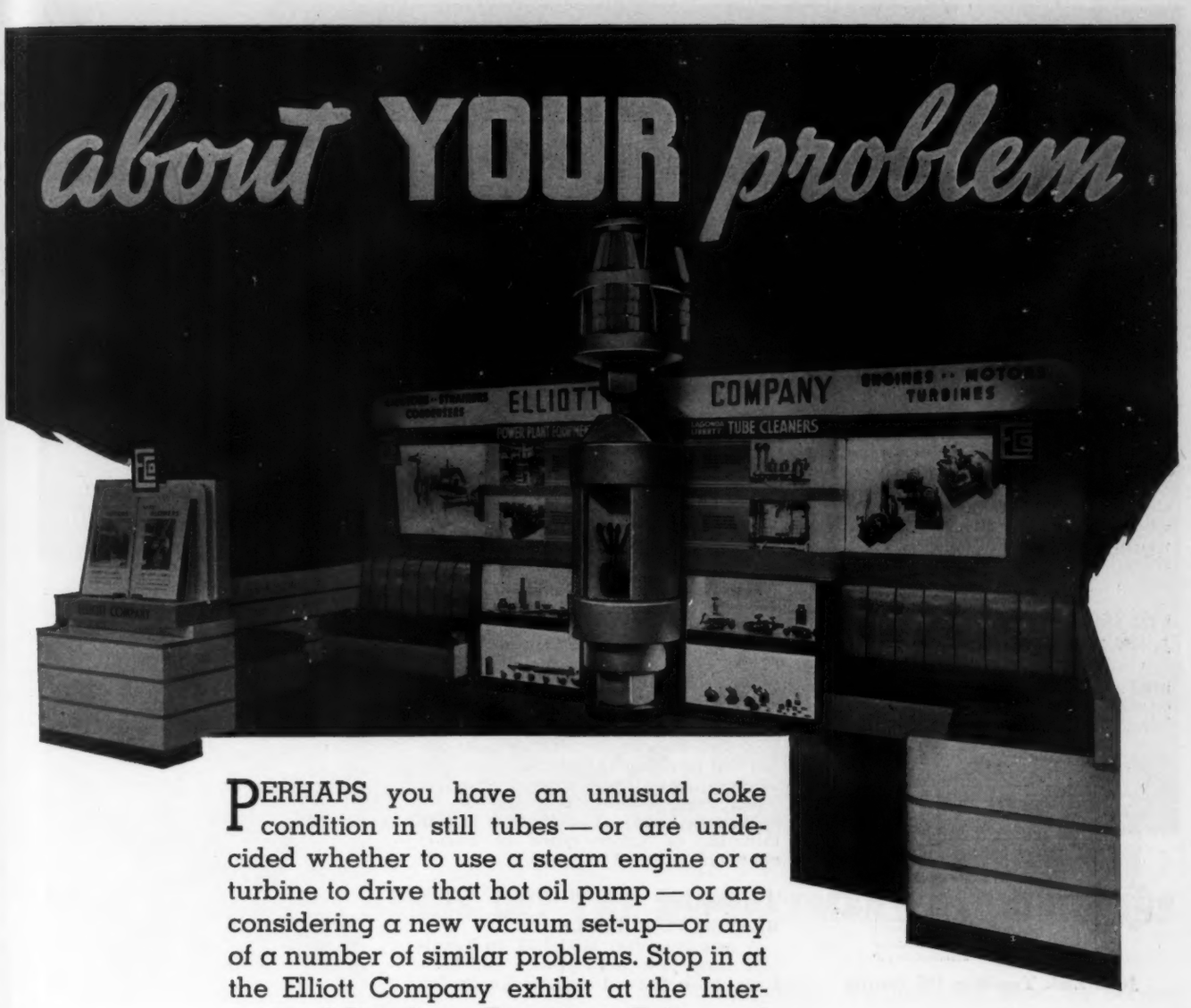
about YOUR problem



PERHAPS you have an unusual coke condition in still tubes — or are undecided whether to use a steam engine or a turbine to drive that hot oil pump — or are considering a new vacuum set-up—or any of a number of similar problems. Stop in at the Elliott Company exhibit at the International Petroleum Exposition, Tulsa, and let's discuss it.

See the latest designs of Lagonda-Liberty tube cleaner heads and motors, and discuss them with men who know refinery tube cleaning. See, pictorially, other Elliott equipment (too large to display) and talk it over with Elliott engineer-specialists who know your needs and are glad to cooperate.

Let's talk about your problem at Tulsa

Q-1067

COMPANY *WORKS:* JEANNETTE, PA.
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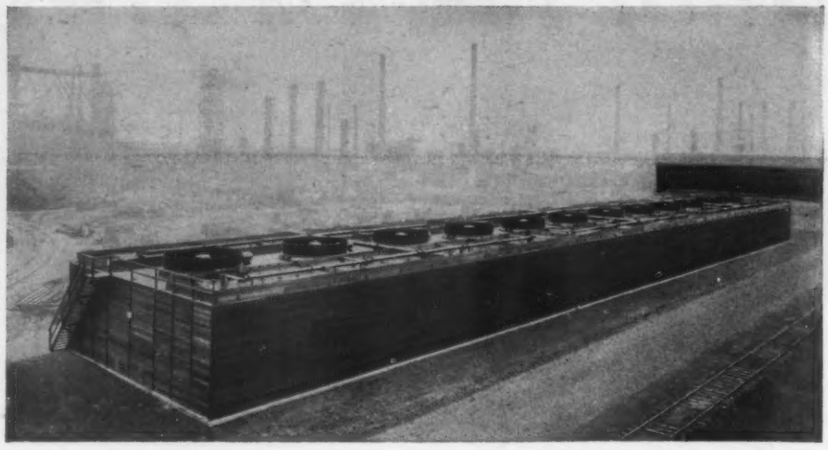
New Equipment for the Modern Plant

Cooling Tower
THE MARLEY COMPANY

A double-flow cooling tower designed for heavy-duty large-capacity service has been announced by The Marley Company, 3001 Fairfax Road, Kansas City, Kansas.

The tower provides horizontal air flow from both sides to the center chamber, from where top fans expel it. Mixture of water with moving air is described as uniformly complete throughout the interior area. Low height and a distribution system requiring no pressure reduce pumping costs and provide operating savings.

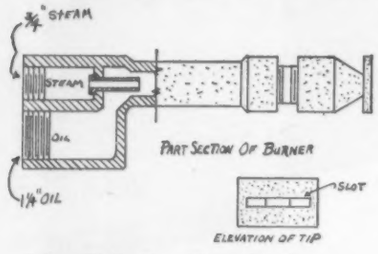
The water system is entirely external, simplifying inspection and maintenance, while style of the tower permits better use of ground areas on crowded plant sites.



Marley Company's Double-Flow Cooling Tower for Large-Capacity Service

Oil Burner
JOHN ZINK COMPANY

A two-way oil burner that may be used as a mechanical atomizing burner or as a semi-mechanical steam atomizing burner by changing heads has been announced by John Zink Company, Tulsa.



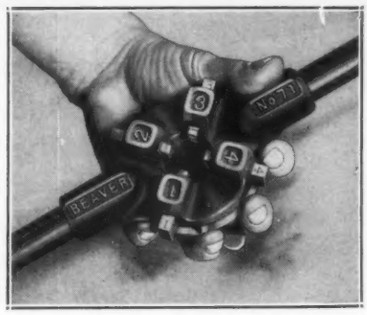
John Zink Two-Way Oil Burner

The mechanical head is a tangential slot-whirl type, while the steam atomizing head may be drilled to produce the type of flame specified. Wall thimbles or air registers of the proper size can be furnished as extra equipment. The oil gun will pass through standard 2-inch pipe, and such pipe can be used as a guide or support to hold it in wall thimbles or other types of burner openings.

Threader
BEAVER PIPE TOOLS

A new threader, Model 71, to handle pipe from ⅛-inch to ¾-inch and bolts from ¼-inch to 1-inch, right or left hand, has been announced by Beaver Pipe Tools, Warren, Ohio.

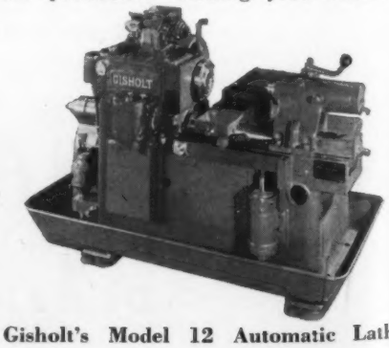
The tool, which may be used with electric power units or hand-operated, is available in ratchet and non-ratchet models. Die bosses project above the face to permit chips to clear instantly and to prevent curls from soft-steel bolt stock from clogging or jamming the tool. Over 100 sets of dies, which can be changed readily, are available.



Beaver Pipe Tools' 71 Threader

Lathe
GISHOLT MACHINE COMPANY

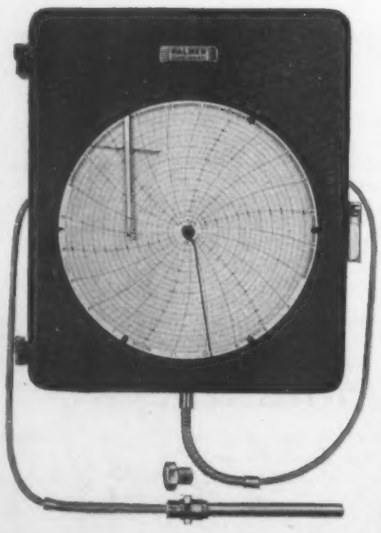
A new hydraulic automatic lathe for between centers and chucking work has been announced by Gisholt Machine Company, Madison, Wisconsin. It is designated Model 12, and is designed for production turning jobs such as



Gisholt's Model 12 Automatic Lathe

Of Vital Importance...

TO YOU TO SEE
Palmer Recorder at Tulsa!



A Recording Thermometer in which you can have confidence in its absolute accuracy, sensitive registration of temperature and superior workmanship. It has been perfected in every detail and is guaranteed by a firm that knows how to make good thermometers.

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KEEPING RETURN BENDS OFF THE REPLACEMENT REQUISITIONS

Return bends in an oil refinery can be either a direct aid to economical operation or a constant drain on the maintenance account. Into which classification they fall depends on the service they give and the frequency with which they appear on replacement requisitions.

Return bends made from 4-6 per cent Chromium-Molybdenum steel qualify in the first category. The steel has good corrosion resistance and retains its strength at elevated temperatures. The Molybdenum content eliminates temper brittleness.

All three qualities are important from the service standpoint, the last named particularly so. It means that bends can be safely cooled to ambient temperatures before removal for cleaning.

Chromium-Molybdenum is one of several Molybdenum steels which are demonstrating their value in day-after-day refinery operation. Complete data on them is contained in our book, "Molybdenum in Steel", a copy of which will be sent free on request to those interested in improved materials.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
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MOLY

gear blanks, cylinder-liners and pistons, small impellers and flywheels.

The lathe provides for a swing of 16¾ inches over the bed, or 12 inches over the front carriage, with a length between centers of 22 inches. The machine has a hydraulic control system to permit handling all functions by means of a single lever. The front carriage and the rear slide have independent hydraulic feed. The machine is equipped with a hydraulically operated main clutch and an automatic spindle brake.

Armor Cutter

IDEAL COMMUTATOR DRESSER COMPANY

A pocket-size cutter to take BX cable, two or three wire, No. 12 or No. 14, has

Ideal Commutator's BX Armor Cutter

been announced by Ideal Commutator Dresser Company, 1531 Park Avenue, Sycamore, Illinois. The tool is described as cutting quickly and cleanly without injury to wire insulation, and as cutting anywhere along length of cable for opening outlets or switch boxes. The cutting blade is removable for sharpening.

Rapid Action **ROTO GUNS Save Time, Men and Money**

Model 112 Air-driven Motor with self-feeding cage-type head and air valve for one-man operation.

The new Rapid Action Roto Gun is as superior to the old type cleaner as the modern machine gun is to the old single shot rifle. With it, one man can clean more tubes by himself in an hour than a team using the old type gun. An air valve on the motor permits him to turn air on and off instantly, without the usual delays caused by signalling a helper.

The tremendous speed and power developed by the new design Roto motor, combined with new types of cutting heads, give you a gun which is setting new performance records everywhere. We'll be glad to prove it in your own plant.

See our Adv. in Sweet's and write

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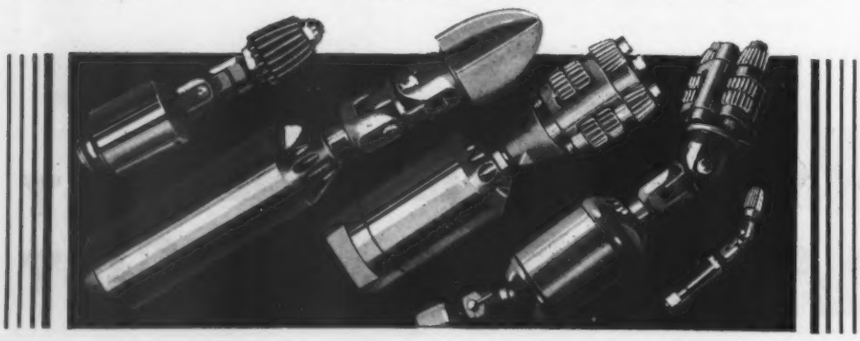
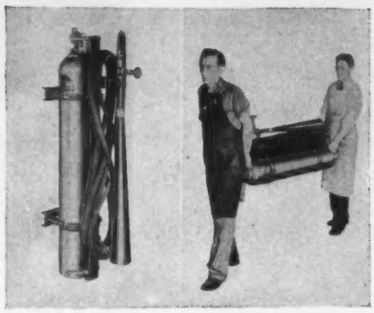
Only ROTO Guns Can Offer You All These Features

- ★ use all available air, without back pressure;
- ★ develop unbelievable speed and power, through new design;
- ★ air valve directly behind the motor permits one-man operation;
- ★ self-feeding cage and swing-frame heads, universal joints and drills have what it takes to do a real job;
- ★ available for straight and curved tubes ½" to 12" I.D.



Fire Fighting Unit

C-O-TWO FIRE EQUIPMENT COMPANY



C-O-Two Fire Fighting Unit

A fire fighting unit that may be clamped to the wall as a fixed-system installation, yet is removable for use as a portable unit, has been announced by C-O-Two Fire Equipment Company, 10 Empire Street, Newark, New Jersey.

The unit consists of a 50-pound cylinder of carbon dioxide, a 50-foot length of high-pressure rubber hose, and a discharge horn fitted with a valve for controlling discharge of gas from the cylinder.

Steel Electrode

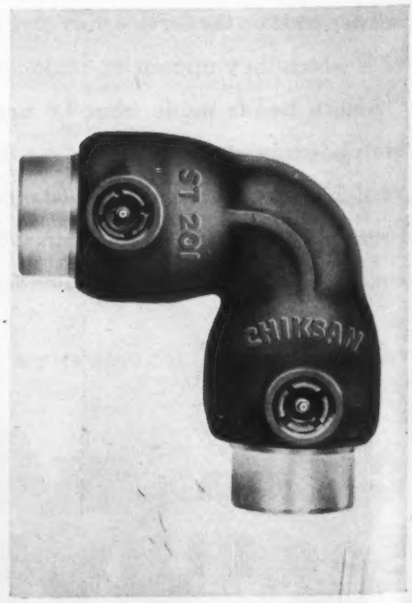
THE LINCOLN ELECTRIC COMPANY

The Lincoln Electric Company, Cleveland, Ohio, has announced Stainweld D as a new stainless steel for arc welding stainless steel of the 25 percent chromium, 20 percent nickel type. It may also be used for welding various stainless steels to mild steel, and for welding steels that are air hardening and cannot be heat treated after welding.

Swing Joint

CHIKSAN TOOL COMPANY

A new swing joint designed for operation at working pressures to 500 pounds and at temperatures up to 700° F., has been announced by Chicksan Tool Company, Brea, California. It is



Chiksan Tool Company Swing Joint

GOOD OIL

. . . worth nothing

Tri-Sure Closures prevent waste like this

● Waste is the enemy of the shipper of drums—but *not* when he uses "Tri-Sure" Closures. When your product is shipped in drums sealed with "Tri-Sure" you *know* that full quantity and full quality will be *delivered.*

"Tri-Sure" Closure Seals are positively leakproof—they can't be removed without deliberately destroying them. They protect every drop of your product from waste, pilferage and substitution.

"Tri-Sure" Closures make every shipment safe—safe for your product and your prestige.

AMERICAN FLANGE & MANUFACTURING CO. INC.
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Reg. U. S. Pat. Off.

DRUM CLOSURES

Make Every Shipment a Safe Shipment

made in 6 styles for full 360-degree rotation in 1, 2 and 3 planes.

Pressure or load is transmitted through double rows of hardened steel balls in flame-hardened races, and the pressure required to force the members apart would have to equal the shearing strength of the metal. A margin of safety is provided as the shearing strength of the metal is in excess of rated capacity of the joint.

The joint is without packing glands or stuffing boxes, and has no nuts or bolts that must be kept tight.

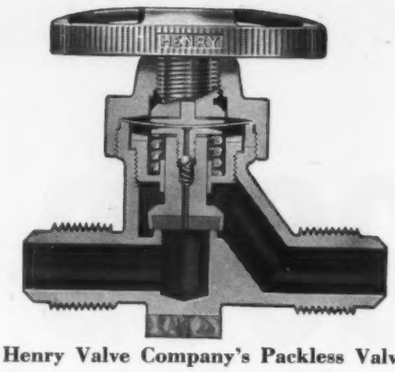
The packing chamber is machined to close tolerances, and then chromium-plated and polished. The packing set is a combination of asbestos and brass rings, and is held in place by the tension of a special alloy wire spring.

Packless Valve

HENRY VALVE COMPANY

A new line of diaphragm packless valves with a balancing-action to provide positive valve opening under all pressure conditions has been announced by Henry Valve Company, 1019 North Spaulding Avenue, Chicago.

The valve features a balancing channel through the axis of the stem to equalize the pressures above and below the seat on opening. The arrangement is said to permit use of a lighter spring, with resultant less wear on the diaphragm. The diaphragm assembly consists of four laminated diaphragms, the top of phosphor bronze to minimize wear, the bottom of stainless steel to guard against corrosion, and the center laminations of a soft bronze to provide a self-sealing action.



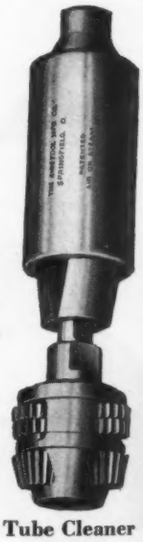
Henry Valve Company's Packless Valve

Handwheels are oval in shape to provide a natural gripping surface. Inlet and outlet parts are directly in line to facilitate installation.

Tube Cleaner

AIRETOOL MANUFACTURING COMPANY

Changes in construction design affecting the cylinder, rotor and rear head of its tube cleaner for power increase without sacrifice of air consumption has been announced by Airetool Manufacturing Company, Springfield, Ohio.



Tube Cleaner

In operation, a rotor with blades maintains contact with the cylinder wall, while a power seal prevents air loss. The device is described as having constant torque at low speeds, as having no dead centers, as operating efficiently at high speeds and starting under heavy loads.

Increased power of the new rotors is designed to permit use of a wide range of cutterhead combinations, formerly limited because of insufficient power. Cutter heads can be provided with two, three or four cutters per row in addition to the cone cutter.

Threading Machine

LANDIS MACHINE COMPANY

A threading machine arranged for reconditioning and threading drill steels or rods has been announced by Landis Machine Company, Waynesboro, Pennsylvania.

The machine employs a three-jawed universal chuck on the machine spindle instead of the conventional revolving-type head, and the die head is mounted

Landis Threading Machine

STREAMLINED OIL HEATER WALLS

Bulk and weight have been eliminated, and so has excess cost from the new Detrick THINSULITE construction of walls and arches in oil refinery heaters.

Even the outside casing can be omitted and in its stead a hard weatherproof finish can be applied in plastic form . . . another saving in cost.

DETRICK

THINSULITE

Detrick THINSULITE Construction involves a completely suspended standard refractory, able to withstand direct exposure to high temperatures . . . flexible enough to remain heat tight and air tight . . . block insulation and a structure of adequate strength.

DETRICK

INSULATION

Detrick is now manufacturing Insulation in three forms—blanket, block and plastic.

Detrick Insulation is particularly fitted for the THINSULITE Construction. It has high insulation value; it resists high temperatures without disintegrating, and it is easy to apply.

Backed by years of engineering experience in the application of insulation for heat conservation, Detrick Insulation can be had to fit any job. Let us send you a sample for test.

Ask for a copy of the THINSULITE Catalog giving details on construction, application and heat transfer curves.

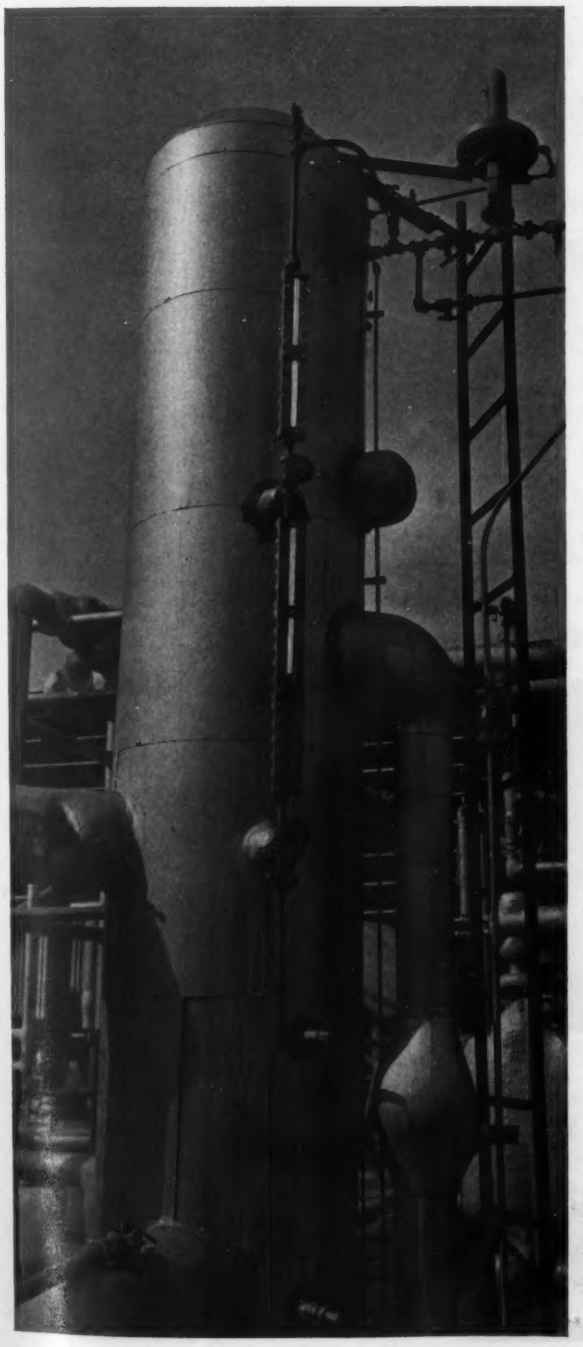
M. H. DETRICK COMPANY

140 SOUTH DEARBORN STREET **CHICAGO, ILLINOIS**

All Three Recycling Plants

on the Towers and Distillation Units of the Tide Water Associated Oil Company and the Seaboard Oil Company . . .

Use JERGUSON Gages



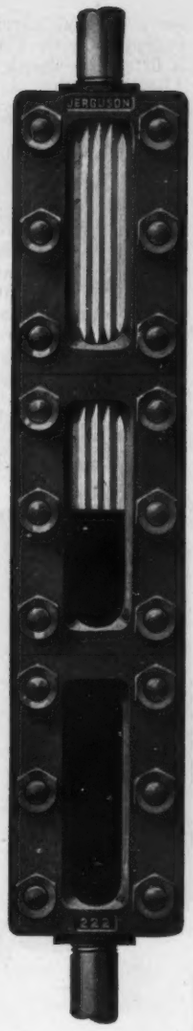
These plants are known as Cayuga No. 1, Long Lake, and Cayuga No. 2. The accumulating tower shown at the left is located at the Long Lake plant, Anderson County, west of Palestine, Texas. The five-section Jerguson Gage on this tower is typical of the installations in all of the plants.

Pressures vary from 1500 lb. per sq. in. down to about 200 pounds.

The sole function of each gage is to indicate *clearly* the level of the fluid, and that is precisely what each Jerguson Gage *does*.

At the same time, to be sure, the gages must be *safe* and *dependable* in operation, qualifications that are assured by the fact that the manufacturers of Jerguson Gages have been engaged in studying, developing, and building them for more than 30 years. All of their products are known to be strictly high grade in every respect.

Regardless of your gage requirements—whether the liquid is gasoline, kerosene, oil, water, or any other—whether it is a tank, tower, still, or boiler—whether the pressure is high or low—whether the liquid is transparent or black—there usually is a Jerguson Gage combination that will fulfill the specifications in every detail.



Close-Up of a smaller Jerguson Gage—Reflex Type—most commonly used in the petroleum industry. The empty space shows WHITE while the liquid shows BLACK. Sizes range from 5" to 84" in length, in single and multiple units. Longer gages can be built in either Reflex or Transparent Types.

Reflex Type. This type, now well known throughout the oil fields of the world, causes the liquid to show BLACK, no matter what its color, while the empty space above shows WHITE.

Transparent Type. These gages are fitted with clear and smooth glass on opposite sides of the liquid chamber, permitting observation THROUGH the gage for noting the color and density of the liquid as well as the level.

Write for Catalog

JERGUSON GAGE & VALVE CO.

87 FELLSWAY
SOMERVILLE, MASS.

on a special carriage. The carriage is equipped with a tail stock into which is fitted the shank of a Landmatic head. The shank has a sliding fit within the bore of the tail stock to permit linear travel of the head. A lever is provided to extend the die head to its most advanced position in the tail stock where it is rigidly clamped into position for thread-cutting operations. All thread-cutting operations are performed with a leadscrew to provide accurate lead control for the thread.

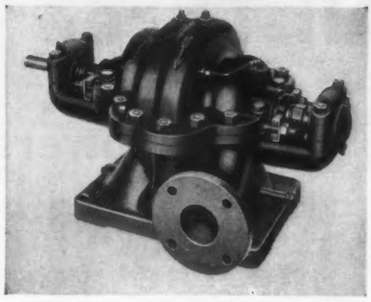
Directly in front of the die head and on the carriage is a cross slide which supports a square turret and which, in turn, can be fitted with turning, facing, forming and cutting-off tools. The turret can be turned to any desired position by unlocking the center post clamping lever. A clamp is provided on the side of the carriage to lock the entire assembly into position during cutting-off operations.

The head is of the pull-off type and provision is made for stopping the forward movement of the carriage. The stop is adjustable and may be synchronized with the leadscrew tripping mechanism to provide threads of uniform length and threading close to a shoulder.

Pumps

FAIRBANKS, MORSE & COMPANY

A line of two-stage, split-case centrifugal pumps for general pumping service where the liquid is of low viscosity and free from foreign matter has been announced by Fairbanks, Morse & Company, 600 South Michigan Avenue, Chicago.



Fairbanks, Morse Two-Stage Pump

One-piece impellers are made of cast iron, hard bronze or other alloy, depending on requirements. They are mounted back-to-back on the shaft for hydraulic balance. Removable wearing rings are provided on both casing and impeller. The shaft, made of alloy steel, is journaled in ball bearings. Centrifugally cast bronze shaft sleeves are mounted on the shaft to protect it against abrasive or corrosive action of the liquid.

The pumps are supplied as basic units, and also as base-mounted units direct-connected to electric motors or steam turbines.

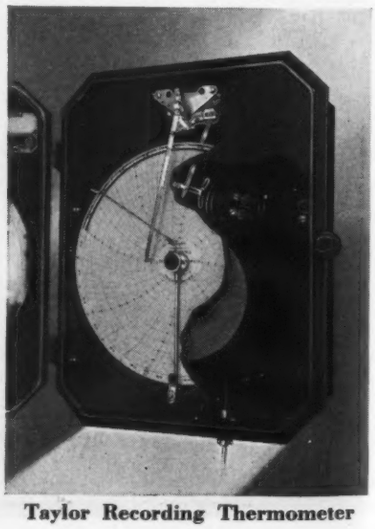
Recorders

TAYLOR INSTRUMENT COMPANIES

A new line of recorders for temperature, humidity, pressure, load, rate of flow, liquid level and receivers for pneumatic transmission systems has been announced by Taylor Instrument Companies, Rochester, New York.

Cases for the recorders are designed for face and flush mounting; standard finish is instrument-black, but white may be had if specified. Dust and moisture are sealed out by Neoprene door gaskets and a bayonet-action latch.

A mechanism combining the chart-locking device and pen lifter facilitates changing charts, and a die-cast aluminum chart plate provides a rigid surface for pencil notations on the chart. The recorders are available with 10- or 12-inch charts, and with 1, 2 or 3 pens. Links, pivots and pen arms employ 18-8 stainless steel. The recorders also feature a new electric chart clock with



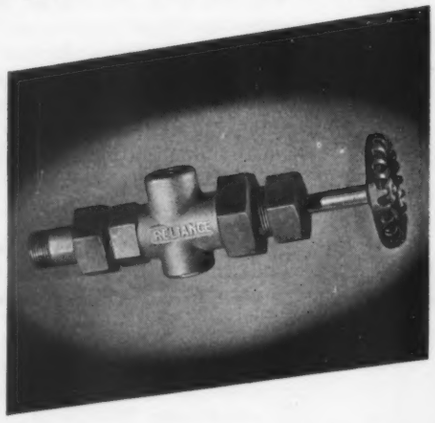
Taylor Recording Thermometer

Extra Protection at a Vital Spot—

Shatter-proof Reliance PRISMATIC INSERTS

Remove the menace of accidents at liquid level gages — help prevent costly damage from spilled inflammable materials by installing Reliance Prismatic Inserts. Thick heat-treated glass is clamped securely in sturdy body — withstands high temperatures and high pressures. Easy, quick to read — liquid shows *black*, empty space *white*. Here's extra protection at gages on various tanks and vessels which prevents serious injury from exploding gage glasses. Thousands in use in many types of service. Write today for Bulletin 391.

Stop your gage valve hazard with Reliance *trouble-proof* Steel Valves



Be sure you have leak-proof valves on vessels holding volatile liquids. Reliance Valves have heavy steel bodies, long-wearing seats and discs, triple-thread quick closing stems. Stand the gaff of heavy service—save money in upkeep expense. Built for pressures up to 2000 lbs. at 750 F. Stainless steel ball check automatic cut-off, if you want it. Write for full information.

The Reliance Gauge Column Company

5902 Carnegie Ave., Cleveland, Ohio

BOILER SAFETY DEVICES since 1884

Reliance

AT OHIO SEAMLESS

Vigilance born of Experience

GUARDS EVERY STEP FROM BILLET TO FINISHED TUBE . .

By long experience we know that no step is unimportant in the manufacture of high quality seamless steel tubing. That is why we give such painstaking attention to every detail

Your interest in **OHIO SEAMLESS STEEL TUBING** quite naturally centers around the question of how it can serve you—meeting your most exacting specifications. That implies an interest in some of the basic reasons why, as well as how, **OHIO SEAMLESS** meets your requirements.

32 YEARS CONTINUOUS OPERATION ★ SHELBY, OHIO BIRTHPLACE OF *Seamless* STEEL TUBE INDUSTRY IN AMERICA

Avoiding technicalities and getting right down to brass tacks, we plan to present the story behind the making of **OHIO SEAMLESS STEEL TUBING** in a way that will answer those questions on both why and how. In the following months we will use this space to take you behind the scenes on a personally conducted tour. We believe you will find it both informative and interesting.

In the meantime we suggest that you consult our sales engineers on any steel tubing problem. They welcome the opportunity of being of service to you.

The OHIO SEAMLESS TUBE CO.
OHIO SPECIAL QUALITY
Shelby, OHIO

REDUCE
YOUR TREATING COSTS *with*
SOLVAY CAUSTIC SODA
MERCAPTAN REMOVAL PROCESS

By using the Solvay Caustic Soda Mercaptan Removal Treating Process, you obtain the following 5 major advantages:

- Substantial savings in "out of pocket" expense of treating chemicals.
- Improved tetraethyl lead susceptibility of the sweetened gasoline.
- Simple conversion of present plant equipment.
- Simple operation of the extracting stage and the caustic soda recovery process.
- Savings that will pay out conversion expense in a short time.

Your inquiries on details of this process and its successful operation in both large and small plants are solicited entirely without obligation to you.

• • •

Solvay maintains a Petroleum Technology Service which is designed to help you solve problems that arise in connection with the use of alkalies for the treatment of gasoline. Please address your inquiries to

SOLVAY SALES CORPORATION

Alkalies and Chemical Products Manufactured by The Solvay Process Company

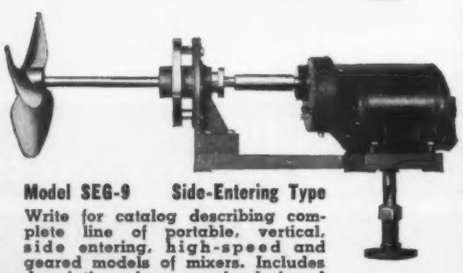
40 RECTOR STREET NEW YORK, N. Y.

BRANCH SALES OFFICES:

Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • New Orleans
New York • Philadelphia • Pittsburgh • St. Louis • Syracuse

All over the world they put it up to EASTERN FOR MIXERS

Wherever mixing enters into the processing of materials, Eastern Engineering staff work has been conspicuously successful. For economy of operation and maintenance, and exact meeting of engineering requirements, it is unquestionably the smart thing to do to "put it up to Eastern."



Model SEG-9 Side-Entering Type

Write for catalog describing complete line of portable, vertical, side entering, high-speed and geared models of mixers. Includes description of our newly designed midget centrifugal pumps.

EASTERN ENGINEERING CO.
55 Fox Street New Haven, Conn.

SEE OUR EXHIBIT AT THE INTERNATIONAL PETROLEUM EXPOSITION

improved coil design, enclosed oil-immersed gears and a slower-speed motor to give longer life. Explosion-proof types are available, and a spring-driven clock is optional.

Steam Trap

V. D. ANDERSON COMPANY

Addition of two new traps to the line of V. D. Anderson Company, Cleveland, has been announced. The head and body are connected with four bolts in a flange-type connection similar to

Anderson Steam Trap

that of larger sized traps. The traps have bronze hexagonal bucket guide tube and the valve and lever mechanism is of a new design with no pins or pivots. The maximum operating pressure for these traps is 200 pounds.

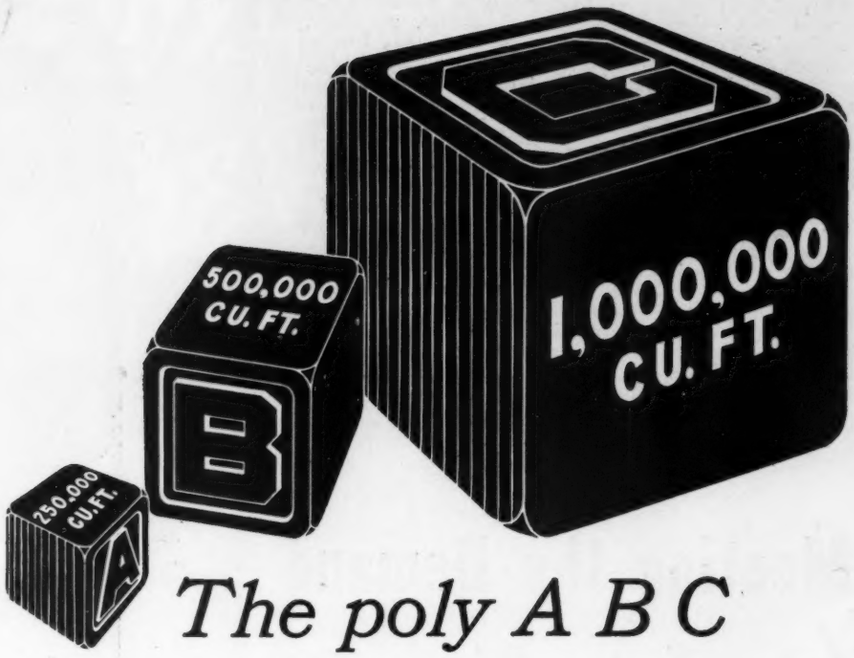
Pillow Block

DODGE MANUFACTURING CORPORATION

Dodge-Timken Pillow Block

A new pillow block designed for simplified mounting on ordinary commercial shafting has been announced by Dodge Manufacturing Corporation, Mishawaka, Indiana. It uses a duplex Timken roller bearing with long extended inner race-ring extending completely through the housing to provide an enclosed bearing.

To secure the bearing to the shaft, collars with two setscrews spaced at 120 degrees are placed on the outside of each end of the extended inner race-ring. The setscrews pass through unthreaded holes in the race-ring, bear directly on the shaft on the one side and clamp the race-ring directly against the shaft on the other side. The race-ring



The poly A B C

Universal has developed three standard-sized U.O.P. catalytic polymerization units to make high octane polymer gasoline from cracked gas—sizes A B and C

Size A is designed to process 250,000 cubic feet of gas per day—suitable for cracking plants making up to 500 barrels of gasoline

Size B is to process 500,000 cubic feet per day—for cracking plants making up to 1000 barrels of gasoline

Size C charges 1,000,000 cubic feet—suitable for cracking plants producing 2000 barrels per day

Construction is rapid, cost is low, profits are remarkable

There's a U. O. P. catalytic poly plant just right for your cracking plant—if you have one

You ought to have both

Universal Oil Products Co
Chicago, Illinois

Dubbs Cracking Process
Owner and Licensor

is clamped throughout its entire length to the shaft and is held by a three-point anchorage at each end.

The pillow block is made in both expansion and non-expansion types. In the non-expansion type, the inner unit is mounted in a two-piece cast iron housing with the inside machined spherical to fit the outside of the inner unit. In the expansion type, the inner unit is mounted in a two-piece cast iron outer housing with the inside machined with a straight cylindrical bore to fit the outside of the inner unit.

The cap and base are machined at the joint to provide an accurate fit and the base of the outer housing is machined to provide accurate backing.

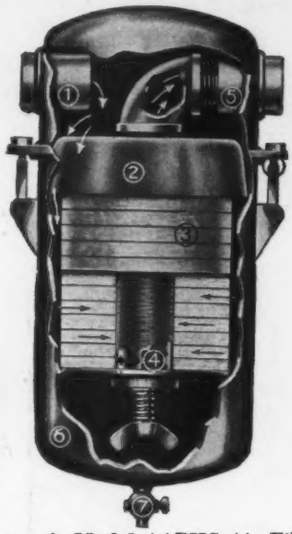
Labyrinth seals are provided to retain lubricant and to protect bearing against foreign material.

Filter

STAYNEW FILTER CORPORATION

A new air filter designed for complete removal of oil, moisture, dust, dirt, pipe scale and other foreign matter from compressed air lines, designated Model AAPHS, has been announced by Staynew Filter Corporation, Leighton Avenue, Rochester, New York.

The filter has a series of discs of a felt-like material carried on a tube composed of an inner liner of perforated metal covered with a fine bronze wire-mesh screen. The tube helps to drain oil removed from the air to the bottom of the filter shell. The lower portion of the filter shell may be removed for inspection or cleaning by loosening the nuts on the swing bolts. A deflector cup is designed to precipitate most foreign matter to the sides of the shell by centrifugal force.



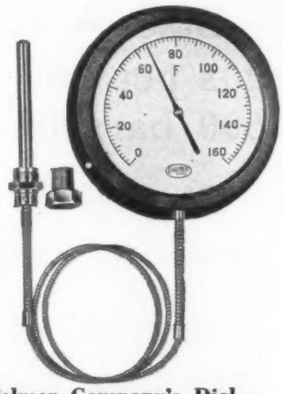
Staynew's Model AAPHS Air Filter

Sizes available range from ¼- to 2-inch pipe size, with filter capacities from 5 to 100 cubic feet a minute, respectively.

Dial Thermometer

THE PALMER COMPANY

A mercury-actuated dial thermometer in an 8-inch case with a scale designed for easy reading at a distance has been announced by The Palmer Company, 2501 Norwood Avenue, Cincinnati, Ohio.



The Palmer Company's Dial Thermometer

Working parts have been styled to operate freely and to give satisfactory service for a long period of time.

Welding Remote Control

WILSON WELDER & METALS COMPANY

A device for remote control of its Hornet arc welders has been announced by Wilson Welder & Metals Company, 60 East 42 Street, New York. The device is employed by replacing it for the handwheel which governs the control pole of the standard welder.

The control allows minute adjustments in current output by touching one of two contacts on the electrode holder to the ground. The motor revolves only when actual contact is maintained. A 1/80 horsepower electric

We're Meeting the Demand for Wilson Tube Cleaners

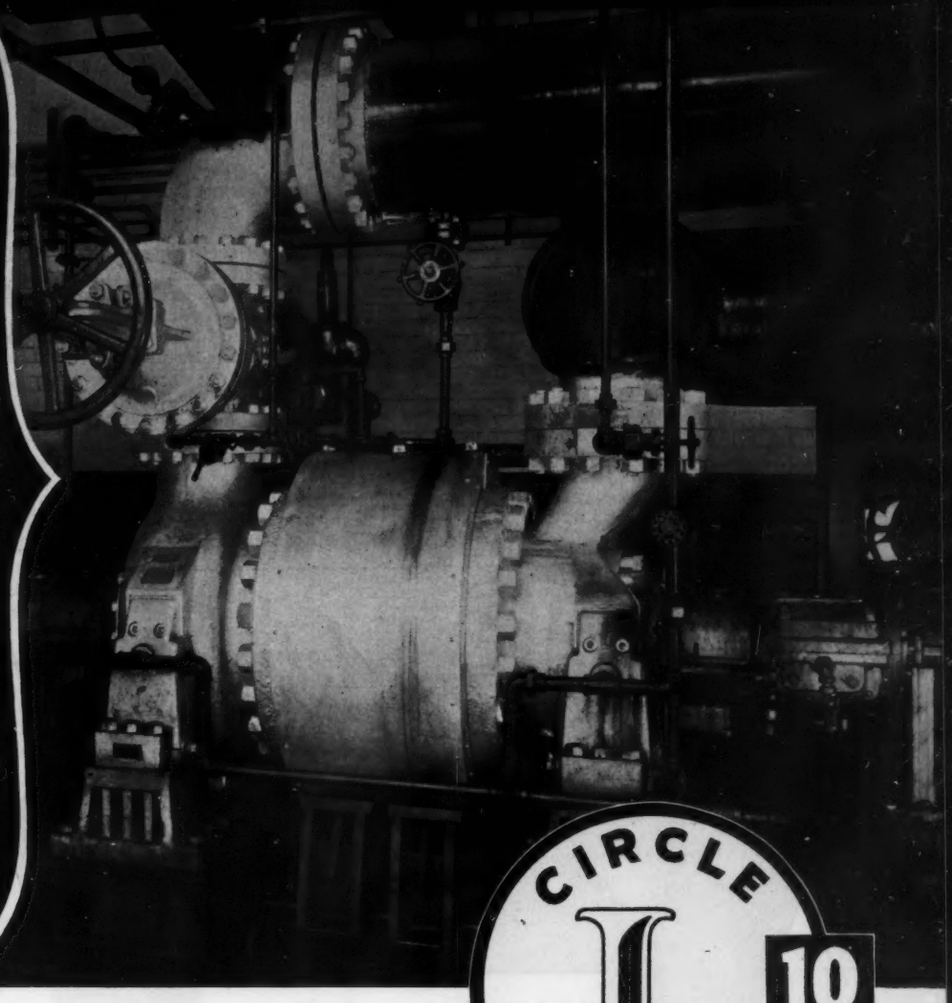
Because we needed more space, more machines and more men to maintain the production schedule our customers' orders for Wilson tube cleaning equipment demanded, we've moved to larger quarters at 47-28 37th Street, Long Island City, N. Y., where we have more than double the floor space that we had in our old plant.

We've installed several new machine tools — we've hired more men — we've increased our capacity and now can make *prompt* shipments of most types and sizes of cleaners from stock. Special sizes can be manufactured and shipped on short notice.

Write for the name of our representative nearest to you or send for our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

800 lbs. pressure at 660° F...



. . . that called for LEBANON Alloy Steel Castings in this Cameron Pump for Richfield's new refinery

AS TEMPERATURES and pressures in oil refineries go up, materials must keep pace. Good-enough-for-yesterday has no place in a modern cracking plant.

When Ingersoll-Rand built the two giant Cameron pumps to charge the cracking heaters in the new Richfield refinery at Watson, Calif., they laid down rigid materials specifications for each part.

With a background of long service to the oil industry, an exceptionally modern foundry practice and complete metallurgical laboratory facilities, Lebanon Steel Foundry was called upon to supply the suction heads and discharge heads for these 1400 GPM giants.

Circle L 10, Lebanon's special alloy for oil refinery service was used. This Chromium Alloy with Molybdenum has high tensile properties combined with high yield point and low creep. It satisfactorily resists corrosive action of hydrogen sulphide and other sulphur gases, wet or dry at temperatures up to 1100° F.

These characteristics have earned it a place as the standard cast steel for modern oil refinery service.

LEBANON STEEL FOUNDRY • LEBANON, PA.

Original American Licensee George Fischer (Swiss Chamotte) Method

CIRCLE L 10

One of the two AHT 6-stage Cameron centrifugal pumps which charge the two cracking units in the new Richfield Oil Corp. refinery at Watson, Calif. Suction heads and discharge heads are Lebanon castings, made from Circle L 10, a special alloy for the oil industry.

Lebanon STAINLESS AND SPECIAL ALLOY Steel Castings

motor that operates the control pole is protected by two limit switches and by a slip clutch to prevent damage when the end of the range is reached. The generator may be pre-set by push buttons mounted on the control.

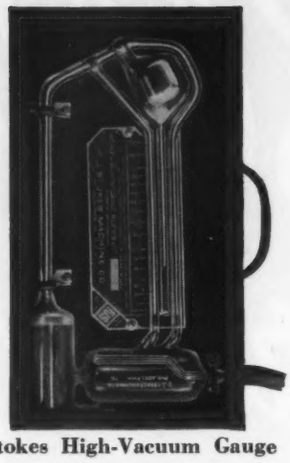
High-Vacuum Gauge

F. J. STOKES MACHINE COMPANY

A new model portable high-vacuum gauge with a range from zero to 700 microns and calibrated down to one-tenth of a micron has been announced by F. J. Stokes Machine Company, Philadelphia. It is designed to enable an operator to take readings quickly and accurately and is built to withstand hard service and constant handling without danger of breakage or damage.

Single readings can be taken with the gauge in a few seconds, and a series of successive readings requires not more than 10 seconds each. The instrument is stood on a level surface, or mounted by means of a swivel bracket provided for the purpose, and then rotated from the horizontal (evacuated) position to the vertical (reading) position. The mercury in the right-hand capillary comes up to the zero mark of its own accord.

The speed of mercury flow when the gauge is rotated is controlled by a restriction in the tubing, lessening the danger of the mercury hammering and breaking the tubing. A trap is provided to prevent the mercury from spilling out, no matter in what position the instrument may be held. The gauge measures 7x13x2-inches and weighs, with mercury, 6 pounds, 3 ounces. It is equipped with "non-breakable" glass front, swivel bracket and carrying handle.



Stokes High-Vacuum Gauge

READABLE.. *Anywhere!*

Out-of-reach doesn't mean out-of-reading range when WESTON Industrial Thermometers are used. Their large, gauge-type faces with bold scale markings are easy to read . . . *and read accurately* . . . a good distance away. That's why you see so many WESTONS on overhead lines, and on equipment in hard-to-get-at locations. In addition, the rigid, all-metal construction of these modern thermometers makes installation easy . . . reduces breakage losses . . . and prevents damage from over-temperatures. Available in sizes, ranges and stem lengths to meet most industrial temperature requirements. Be sure to send for catalog. Weston Electrical Instrument Corporation, 655 Frelinghuysen Avenue, Newark, N. J.

WESTON

GAUGE-TYPE... ALL METAL

THERMOMETERS

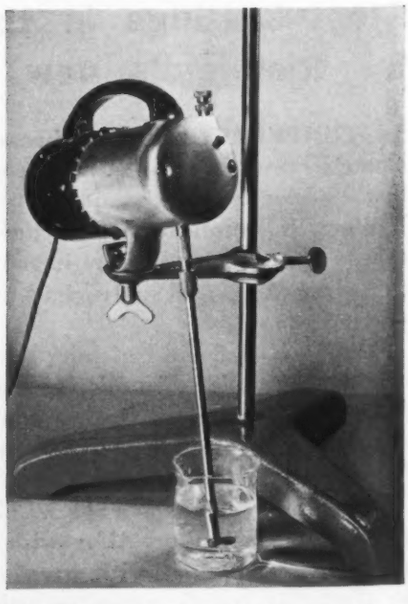
Gas Hose

THE B. F. GOODRICH COMPANY

A new line of hose designed for handling butane and propane gases has been announced by The B. F. Goodrich Company, Akron Ohio. It is of combination construction with synthetic tube and rubber cover and is offered in sizes from ⅜-inch to 3 inches in diameter. Sizes from ½-inch and larger have built-in static wire.

Mixer

MIXING EQUIPMENT COMPANY



Mixing Equipment's Laboratory Mixer

An addition to its line of laboratory mixers has been announced by Mixing Equipment Company, 1062 Garson Avenue, Rochester, New York. Designated Model F, it is available for 110- or 220-volt, 60-cycle, one phase current.

The mixer is described as providing constant horsepower at the propeller and increasing torque with slow speeds. Speed is regulated by a thumb screw, with a range of a few to 1750 revolutions per minute.